JOURNAL OF DAIRY SCIENCE

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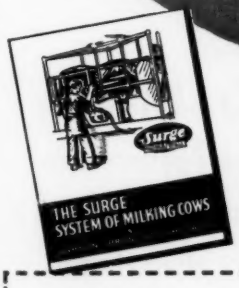

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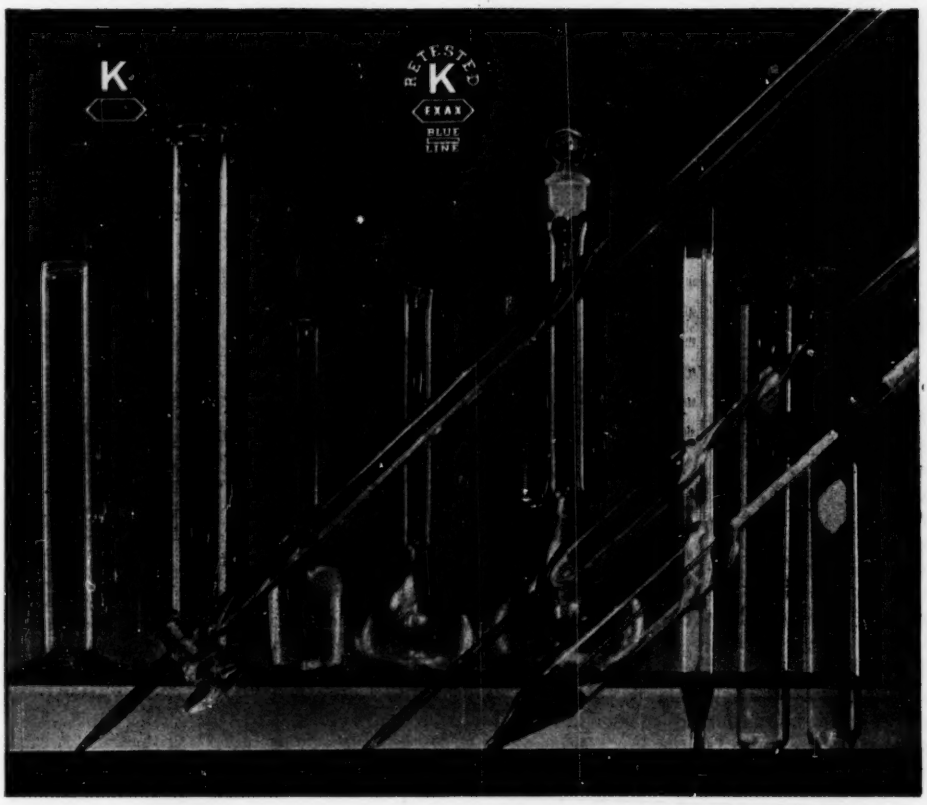

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JOURNAL OF DAIRY SCIENCE

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CANADIAN CHEDDAR CHEESE FROM PASTEURIZED MILK

J. J. JANZEN AND R. W. BROWN

Department of Dairy Science, The University of Manitoba, Winnipeg

INTRODUCTION

In Canada, pasteurization in the dairy industry has been adopted very generally except in the manufacture of Cheddar cheese. However, because a number of epidemics of typhoid fever occurring in recent years in different parts of Canada have been traced to infected Cheddar cheese, the making of this kind of cheese from pasteurized milk has become an issue. Outside of the economies involved in the application of pasteurization to cheese making, the chief difficulty lies in the belief, among some authorities, that pasteurization sacrifices the typical Cheddar cheese flavor.

There were two chief objects in making this study. The first and foremost was to find out how well Cheddar type cheese made from pasteurized milk would meet Canadian market requirements, as indicated by the Canadian system of scoring and grading cheese by officials of the Marketing Service of the Dominion Department of Agriculture. Until now, no extended study of this nature has been made. The second object was the employment of pasteurization processes which would produce effective results according to the phosphatase tests and thus meet public health requirements in this regard.

While the public health measure in Canada, requiring the holding of cheese for 90 days before being sold to the consumer, applies both to cheese made from pasteurized and unpasteurized milk, the inclusion of pasteurized milk cheese under this regulation is not an issue at present because no factory in Canada is yet using pasteurized milk for Cheddar cheese. If and when this should be done, the authors believe it should be feasible to protect the milk and the curd from recontamination by employing common medical and sanitary measures in the factory.

HISTORICAL

A number of epidemics, traced to Cheddar cheese, have been reported in recent years (1, 3, 5, 9). Bowman (1) reported three separate outbreaks of typhoid fever in Manitoba, traced to Cheddar cheese. Gauthier and Foley (5) reported a large outbreak in Quebec and recommended pasteurization of cheese milk and a minimum holding period of 3 months for raw milk cheese prior to selling such cheese to the consumer. During 1945, 6 of the 24 reported epidemics traced to milk and milk products in the U. S. A. were due to Cheddar

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cheese (3). Fabian (4) presents a well balanced review and discussion of disease outbreaks traceable to cheese.

Campbell and Gibbard (2) found that, under experimental conditions, most of the *Eberthella typhosa* organisms were dead in cheese held at 58–60° F., after a storage period of 3 months. However, similar cheese held at 40–42° F. retained viable typhoid organisms for at least 6 and in a majority of cases for 10 or more months.

Price (7, 8) reports that pasteurization of milk for cheese making results in an increased yield and improves the uniformity and keeping quality of the cheese. Review of earlier literature and experimental work is well covered in one of these papers (7). Tuckey (9) reports results which are in close agreement with those of Price (7) with respect to yield and keeping quality of the cheese. Irvine *et al.* (6) reported no increased yields where pasteurized milk was used. However, they did notice a significant improvement in butterfat retention in the pasteurized milk cheese.

Walter and Lochry (10) found that no. 1 cheese was increased where pasteurization was employed even though the no. 1 production was high prior to pasteurization. Wilson *et al.* (12) found that cheese made from pasteurized milk of good quality and with proper control of acid development could be ripened safely at a temperature high enough to permit the continued activity of essential bacteria.

EXPERIMENTAL PROCEDURE

All the experimental cheese was made during the months of June and July in the Department of Dairy Science, The University of Manitoba. Small vats holding 450 lb. of milk were used. The milk when received was mixed and divided into two lots of approximately 400 lb. each. One lot was used without heat treatment, whereas the second was either vat pasteurized, vacreated or pasteurized by the HTST method. The vat pasteurization procedure consisted of heating the milk to a temperature of 143–145° F. and holding for 30 minutes at that temperature, after which it was surface cooled to 35–40° F. The vacreation process consisted of preheating to a temperature of 145° F. for 5–10 minutes in a vat pasteurizer, after which the milk was run through a Vacreator at a temperature of 162–165° F., followed by cooling to 35–40° F. over a surface cooler. The HTST treatment consisted of heating the milk to 161–162° F. for 15–16 seconds followed by cooling in the regenerative and cooling sections of a plate pasteurizer.

Each series consisted of 12 split vats, the difference between the series being the type of pasteurization treatment employed. The pasteurized milk in each case was heated and held for periods sufficient to give a negative phosphatase test. Both raw and pasteurized lots of milk were held in a cold storage overnight, after which the milk was transferred to the cheese vats. Both batches were raised to the ripening temperature. An active starter then was added, ranging from 0.5 to 2 per cent for the pasteurized milk and 0.25 to 1.75 per cent for the unpasteurized milk. An average of 0.015 to 0.025 per cent acid was developed before setting in both cases.

TABLE 1

Time, temperature and acidity schedules of experimental cheese from pasteurized milk

Operation	Time of operation	Time to next step		Temp.	Av. acidity
		(*hr.*)	(*min.*)	(° *F.*)	(%)
Add starter	8:30	1	0	86	0.155
Setting	9:30	0	30	86	0.179
Cutting	10:00	0	15	86	0.118
Steam on	10:15	0	30	86	.....
Steam off	10:45	1	0	102	.....
Dipping	11:45	0	15	102	0.153
Cheddaring	12:00	3	0	102	0.175
Milling	3:00	0	15	94	0.511
Salting	3:15	0	30	90	.....
Hooping and pressing	3:45	0	30	86	.....
Dressing	4:15	Overnight		.....	.....

The time, temperature and acidity schedules followed in making cheese from pasteurized milk are set forth in table 1. Table 2 compares the amounts of starter used and acidities at various stages for both the raw and pasteurized milk cheese. Wilson's (11) manufacturing procedure was followed for the pasteurized milk cheese. The raw milk cheese schedule was based on acid development at the different stages. Cheddaring was accomplished by piling the curd on both sides of the vat and letting it mat. After sufficient matting, the curd was cut into suitably sized slabs and turned every 10–15 minutes. The slabs were piled two and three high as cheddaring advanced, depending on the rapidity of the draining process. Completion of the cheddaring process was ascertained by the development of acid and a smooth, meaty texture of the matted curd. The milling and salting procedures were very similar to those used in the pasteurized milk.

The temperature of the curd at the time it was weighed and put into four Stilton-size hoops was 86° F. The hoops were placed in the press for 30 minutes and then taken out, the cheese properly dressed, replaced and left in the press overnight.

Two cheese of each lot of four were paraffined at a temperature of 220° F. for 10 seconds, whereas 2 of each lot were left unparaffined. This latter feature

TABLE 2

Comparisons of average percentages of starter used and acidities developed in the manufacture of Cheddar cheese from raw and pasteurized milk

Operation	Raw milk	Pasteurized milk
% starter used	0.89	1.48
Initial milk acidity (%)	0.175	0.155
Setting acidity (%)	0.193	0.179
Cutting acidity (%)	0.132	0.118
Dipping acidity (%)	0.178	0.153
Cheddaring acidity (%)	0.229	0.175
Milling acidity (%)	0.595	0.511

TABLE 3

Distribution of flavor scores for 80 cheese, from 12 split vats, raw and vat pasteurized, cured at 45 and 58° F., 48 paraffined and 32 unparaffined. Age = 3 mo.

Flavor score	No. of cheese in each classification							
	Raw				Vat pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
40 and over	0	0	0	0	5	4	6	5
39 to 39.9	5	3	4	1	7	7	2	3
38 to 38.9	4	6	3	6	0	1	0	0
35 to 37.9	3	3	1	1	0	0	0	0

was not included in the first four split vats. They then were placed in the curing room having a temperature of 58° F. until the first scoring period, after which one of each of the paraffined and unparaffined cheese was stored at 45° F., while the other pair was stored at 58° F.

TABLE 4

Distribution of flavor scores for 96 cheese, from 12 split vats, raw and vacreated, cured at 45 and 58° F., 48 paraffined and 48 unparaffined. Age = 3 mo.

Flavor score	No. of cheese in each classification							
	Raw				Vacreated			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
40 and over	1	0	1	0	6	4	6	3
39 to 39.9	7	5	6	5	6	8	6	8
38 to 38.9	3	4	4	5	0	0	0	1
35 to 37.9	1	3	1	2	0	0	0	0

All of the cheese were scored at ages of approximately 10 days, 3 months and 11 months. This was done by two, sometimes three, Dominion Dairy Produce Graders, without any knowledge on their part as to the treatment of the cheese except that they were experimental lots.

TABLE 5

Distribution of flavor scores for 96 cheese, from 12 split vats, raw and HTST pasteurized, cured at 45 and 58° F., paraffined and unparaffined. Age = 3 mo.

Flavor score	No. of cheese in each classification							
	Raw				HTST			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
40 and over	0	0	0	0	1	1	2	0
39 to 39.9	0	0	1	0	7	7	9	10
38 to 38.9	7	3	4	2	4	4	1	2
35 to 37.9	5	9	7	10	0	0	0	0

TABLE 6

Distribution of flavor scores for 272 cheese, from 36 split vats, all raw and all pasteurized combined, cured at 45 and 58° F., 144 paraffined and 128 unparaffined. Age = 3 mo.

Flavor score	No. of cheese in each classification							
	All raw				All pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
40 and over	1	0	1	0	12	9	14	8
39 to 39.9	12	8	11	6	20	22	17	21
38 to 38.9	14	11	11	13	4	5	1	3
35 to 37.9	9	17	9	13	0	0	0	0

RESULTS AND DISCUSSIONS

Scores at three ages were obtained and recorded. Since the data obtained were of necessity quite extensive, considerable condensing was necessary. The flavor score distributions for the 3-month old cheese, being representative of all, have been condensed and set forth in tables 3, 4, 5 and 6.

The Canadian scale of points for scoring cheese is as follows: Flavor—45 points, Texture—25 points, Closeness—15 points, Color—10 points, Finish—5 points.

Flavor and total score ranges for the various grades are as follows:

Grade of cheese	Flavor score range	Total score range
First	39 – 45	92 and over
Second	37 and under 39	87 and under 92
Third	35 and under 37	85 and under 87
Below Third Grade	No score given	

That the use of pasteurized milk results in a more uniform and improved quality cheese has been adequately shown in tables 3, 4, 5 and 6. Table 7 compares the total scores of 36 pairs of raw and pasteurized lots of cheese revealing the predominant preference for the pasteurized milk cheese.

TABLE 7

Distribution of total scores for 240 cheese, from 36 split vats, raw and pasteurized, cured at 45 and 58° F., 128 paraffined and 112 unparaffined. Age = 3 mo.

Total score	No. of cheese in each classification							
	All raw				All pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
92 and over	14	10	13	9	27	26	28	27
87 to 92	17	12	14	17	5	6	0	1
85 to 87	1	10	1	2	0	0	0	0

Differences in flavor scores between paraffined and unparaffined cheese of

TABLE 8

Average flavor scores at 10 days, 3 months and 11 months, for 80 cheese, from 12 split vats, raw and vat pasteurized, cured at 45 and 58° F., paraffined and unparaffined

Age	Raw				Vat pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
10 days	39.2	39.2	39.2	39.2	39.6	39.6	39.6	39.6
3 mo.	38.5	38.1	38.7	38.4	39.6	39.4	39.9	39.7
11 mo.	37.8	37.1	37.7	37.2	39.2	38.8	39.0	38.5

the raw and pasteurized groups are not very significant. However, the total score grade distribution shows a slight preference for the unparaffined lots.

Tables 8 through 11 portray the influence of the 3 heat treatments on the flavor of the cheese at 10 days, 3 months and 11 months.

The average flavor scores reveal a very distinct trend for the better in the pasteurized milk cheese. The older the cheese the greater the difference in

TABLE 9

Average flavor scores at 10 days, 3 months and 11 months, for 96 cheese, from 12 split vats, raw and vacreated, cured at 45 and 58° F., paraffined and unparaffined

Age	Raw				Vacreated			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
10 days	38.8	38.8	38.8	38.8	39.7	39.7	39.7	39.7
3 mo.	38.9	38.5	38.8	38.7	39.7	39.4	39.6	39.4
11 mo.	38.1	37.8	38.2	37.8	39.3	39.0	39.1	39.0

flavor score between raw and pasteurized, indicating better keeping quality of the pasteurized milk cheese. The average increases in flavor scores for the pasteurized milk cheese were 0.6 points at 10 days, 1.2 points at 3 months and 1.6 points at 11 months.

Expressed on a percentage grade distribution basis, the results indicate that pasteurization improved the flavor score considerably at both the 3 month and 11 month gradings, as shown in tables 12 and 13. Based on total scores, the

TABLE 10

Average flavor scores at 10 days, 3 months and 11 months, for 96 cheese, from 12 split vats, raw and high-temperature-short-time pasteurized, cured at 45 and 58° F., paraffined and unparaffined

Age	Raw				HTST			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
10 days	38.2	38.2	38.2	38.2	38.6	38.6	38.6	38.6
3 mo.	38.7	36.6	37.7	37.2	39.1	39.0	39.2	39.0
11 mo.	36.3	35.0	37.2	35.5	39.0	38.6	38.7	38.9

TABLE 11

Average flavor scores at 10 days, 3 months and 11 months, for 288 cheese, from 36 split vats, raw and pasteurized, cured at 45 and 58° F., paraffined and unparaffined

Age	All raw				All pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
10 days	38.7	38.7	38.7	38.7	39.3	39.3	39.3	39.3
3 mo.	38.7	37.7	38.4	38.1	39.4	39.3	39.6	39.4
11 mo.	37.4	36.7	37.7	36.8	39.2	38.8	38.9	38.8

percentage grade distribution at 3 months of age (table 14) also shows a marked preference for the pasteurized milk cheese.

On a percentage grade distribution basis, the first grade ratio of raw milk cheese to pasteurized milk cheese was 1:2 to 1:3 at 3 months of age. At 11 months this ratio was 1:4 to 1:6, depending on whether the cheese were paraffined or not, also the curing temperatures. Both uniformity and better quality can be achieved in Cheddar cheese made from pasteurized milk.

TABLE 12

Percentage grade distribution at 3 months, based on flavor score, for 288 cheese, from 36 split vats, raw and pasteurized, cured at 45 and 58° F., paraffined and unparaffined

Flavor grade	All raw				All pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
First	44.4	30.6	43.7	28.1	97.2	94.4	100.0	96.9
Second	52.8	47.2	46.9	62.5	2.8	5.6	.....	3.1
Third	2.8	22.2	9.4	9.4	.....	.....	.....	.....

The raw milk cheese definitely did not stand up as well at 58 as at 45° F., which is quite logical. However, the difference between these two temperatures for the pasteurized batches was relativly small, indicating the possibility of utilizing a higher curing temperature to compensate, in part, for the delayed curing at 45° F. Curing temperatures of 58° F. or slightly higher are readily applicable to cheese made from properly pasteurized milk in which the flora is controlled.

TABLE 13

Percentage grade distribution at 11 months, based on flavor score, for 288 cheese, from 36 split vats, raw and pasteurized, cured at 45 and 58° F., paraffined and unparaffined

Flavor grade	All raw				All pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
First	22.2	13.9	21.9	12.5	86.1	75.0	81.2	84.4
Second	41.7	36.1	43.7	46.9	11.1	22.2	15.6	12.5
Third	36.1	50.0	34.4	40.6	2.8	2.8	3.1	3.1

The higher temperatures favor more rapid activity of the essential bacteria, thus hastening the curing process. The use of a curing temperature of 58° F. for raw milk cheese does not seem practicable because of the possibilities of off-flavor development.

One of the main criticisms of the use of pasteurized milk for making Cheddar cheese has been, and still is, the alleged lack of typical Cheddar flavor development. The authors have, on frequent occasions, examined some of the experimental cheese and found the pasteurized cheese to possess a good, clean Cheddar cheese flavor, more mild, mellow and uniform than that of the raw milk counterparts. The use of a higher (58° F.) curing temperature for pasteurized milk cheese will counteract the slow curing obtained at lower temperatures, yet will not forfeit the clean typical Cheddar flavor.

A preference study was made during a previous season using samples of cheese made from split vats of raw and pasteurized milk. These were obtained

TABLE 14

Percentage grade distribution at 3 months, based on total score, for 288 cheese, from 36 split vats, raw and pasteurized, cured at 45 and 58° F., paraffined and unparaffined

Total score grade	All raw				All pasteurized			
	Paraffined		Unparaffined		Paraffined		Unparaffined	
	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.	45° F.	58° F.
First	43.7	31.2	46.4	32.1	84.3	81.2	100.0	92.8
Second	53.1	37.5	50.0	60.7	15.7	18.8	.....	7.2
Third	3.2	31.3	3.6	7.2	.....	.....	.....	.....

from 8 pairs of cheese 10 months old. Samples were distributed among members of the University Staff, the Staff of the Dairy Branch of the Manitoba Department of Agriculture and that of the Winnipeg Office of the Marketing Service of the Dominion Department of Agriculture. Each recipient was asked to indicate his or her preference between the two samples which were labelled *A* and *B*. Of the 37 replies received, 20 preferred the pasteurized milk cheese, 15 preferred the raw milk cheese and 2 indicated no preference. This study, though carried out on a small scale, does reveal the preference tendency.

SUMMARY

1. The average flavor scores of 288 cheese, made from raw and pasteurized milk, were in favor of the pasteurized milk cheese. The average flavor score increase at three separate gradings was 0.6 points at 10 days scoring, 1.2 points at 3 months scoring and 1.6 points at 11 months scoring.

2. The quality of the cheese, based on the flavor score obtained at 3 months of age, showed that 28.1–44.4 per cent of the raw milk cheese and 94.4–100 per cent of the pasteurized cheese were first grade. The percentage range depended on whether the cheese were paraffined or not and also on the curing temperatures employed. At 11 months of age, the percentages were 12.5–22.2 per cent

and 75.0–86.1 per cent, respectively, for the raw and pasteurized cheese. The balance of the samples in each case were of second-grade quality or lower.

3. Of 37 preference reports received, 54 per cent favored pasteurized milk cheese, 6 per cent indicated no preference while 40 per cent preferred raw milk cheese.

ACKNOWLEDGEMENTS

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REFERENCES

(1) Bowman, Maxwell. An Epidemic of Typhoid Fever Due to Infected Cheese. Can. Pub. Health J., 33; 11: 541. 1942.

(2) Campbell, A. G., and Gibbard, J. The Survival of E. typhosa in Cheddar Cheese Manufactured from Infected Raw Milk. Can. Pub. Health J., 35, 4: 158–64. 1944.

(3) Editorial. Public Health Service Disease Outbreak Reports, 1945. J. Milk Technol., 10, 3: 125–127. 1947.

(4) Fabian, F. W. Cheese as the Cause of Epidemics. J. Milk Technol., 9, 3: 129–142. 1946.

(5) Gauthier, J., and Foley, A. R. A Cheese-Borne Epidemic of Typhoid Fever. Can. Pub. Health J., 34, 12: 543. 1943.

(6) Irvine, O. R., Bryant, L. R., Hill, D. C. and Sproule, W. H. A Comparison of the Yield of Cheddar Cheese Obtained from Raw, Holder Pasteurized and HTST Pasteurized Milk. J. Dairy Sci., 30, 8: 530–31. 1947.

(7) Price, W. V. Cheddar Cheese from Pasteurized Milk. J. Dairy Sci., 10: 155–68. 1927.

(8) Price, W. V. Can Pasteurized Milk Cheese Compete with Raw Milk Cheese? Natl. Butter Cheese J., 35: 32–3. Nov. 1944.

(9) Tuckey, S. L. Making Cheese from Pasteurized Milk. Natl. Butter Cheese J., 27, 23: 22. 1936.

(10) Walter, H. E., and Lochry, H. R. The Manufacture of Cheddar Cheese from Pasteurized Milk in Commercial Plants. J. Dairy Sci., 28, 8: 597–606. 1945.

(11) Wilson, H. L. Making American Cheddar Cheese of Uniformly Good Quality. USDA Mimeo. BDIM-947. 1942.

(12) Wilson, H. L., Hall, S. A., and Rogers, L. A. The Manufacture of Cheddar Cheese from Pasteurized Milk. J. Dairy Sci., 28, 3: 187–200. 1945.

STANDARDIZING HAY PALATABILITY TRIALS WITH CALVES

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The more palatable the hay, generally speaking, the greater is the consumption of it by calves. The problem of producing palatable hay is not confined to Wyoming, for this problem has no geographical boundaries. In Wyoming, however, the farmer's grain supply usually is limited, and he is more likely to have an ample supply of hay. The quality of the hay, consequently, is of great importance in the proper development of young stock in this state, because of the large place this feed occupies in the calf ration.

There is no known chemical method of testing for palatability of hay. There are some chemical constituents which, by their presence or absence, affect palatability, among them protein and sugar, but the amount of these present is not always directly correlated with how well cattle like the feed (1). Chemical methods, for example, cannot measure physical characteristics, such as brittleness of stems. Measurement of palatability of hay must be accomplished by feeding it to the class of livestock for which it is intended. The accuracy of this method depends upon the repeatability of results. Variability of consumption of the same hay, as determined by experimental method, must be controlled so that the various factors influencing palatability, such as type of soil, time of cutting and method of curing, may be studied during several growing seasons with the assurance that the methods used will give comparable results from one season to another.

The author, in this paper, has confined himself to experiments in devising a method for determining palatability of hay fed to calves. The disclosure of certain factors influencing palatability, such as variety or time of cutting, is purely incidental to the main objective.

A number of years ago, the author determined that hay allowance, within certain limits, made a considerable amount of difference in the amount of hay consumed by calves when other factors were constant (2). Hay consumption followed the hay allowance closely; when hay allowance went up, hay consumption went up.

Several factors in this experiment made it difficult to measure the exact effect of hay allowance on hay consumption. For one thing, as the calves grew older, the grain allowance was changed so that the total ration would conform with the Morrison Standard for total digestible nutrients. This meant that the grain allowance was lowered as the hay allowance was increased, so that it was difficult to ferret out which factor influenced consumption the more. Then too, it was shown that when hay consumption was calculated per 100 lb. live weight, hay consumption per hundredweight increased as the calves grew older. Here again, a question arose as to whether the increase in capacity and appetite or the increase in hay allowance caused an increase in hay consumption.

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EXPERIMENTAL PROCEDURE

In an attempt to answer some of these questions, three types of hay (table 1) were fed to calves ranging in age from 3 to 12 months. Altogether, 34 head of Holstein females were fed in individual box stalls so that daily hay refusals could be ascertained.

The calves were given a grain mixture which consisted of three parts ground barley, three parts ground oats and one part wheat bran. One per cent common salt was added to this mixture. The grain allowance depended to some extent upon the calf's weight and age. When a calf was underweight, more grain was fed in an attempt to bring the calf back to normal weight. The milk allowance varied, in some cases being fed only until the calf reached 60 days of age, in other cases for periods of up to 150 days of age. Both whole and skim milk were included in the rations. The amount of milk fed was reflected in the calf weights, the calves

TABLE 1

The chemical analysis of the three types of hay

	H_2O	*E.E.*	*Fiber*	*Crude Pro.*	*N.F.E.*	*Ca*	*P*
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Alfalfa, second cutting, good quality	10.0	2.65	21.69	17.29	40.48	1.46	0.22
Alfalfa, second cutting, poor quality	11.8	1.53	30.68	13.60	35.39	1.56	0.18
Native hay from the Laramie Plains	10.0	2.14	31.90	7.10	43.05	0.29	0.14

getting smaller amounts of milk or getting it for shorter periods of time usually being under normal weight at the time they were weaned.

The feed allowed and consumed was plotted against age and weight of each individual calf in order to secure the hay fed and consumed at definite weights and ages. The feed allowed and consumed then was interpolated at 10 lb. and 10 day intervals. Charts were made using the mean of each group of calves.

RESULTS

Weight, age, and hay quality affect results. Figures 1 and 3 show the relationship between the live weight of the calves and their hay consumption, as well as the influence of the amount of hay placed before the calf. Figures 2 and 4 show the relationship between the age of the calves and their hay consumption, plus the influence of the amount of hay offered.

An attempt was made in this feeding experiment, as was mentioned earlier, to correct the ration for weight and age. There also was a correction for the difference in quality of hay. The less palatable alfalfa was of a poorer feeding quality, and accordingly, more was offered to compensate for the feeding deficiency. Likewise, some attempt was made to correct the somewhat slower growth of the calves getting low grade alfalfa by adding more grain to the ration when the animals lagged in growth.

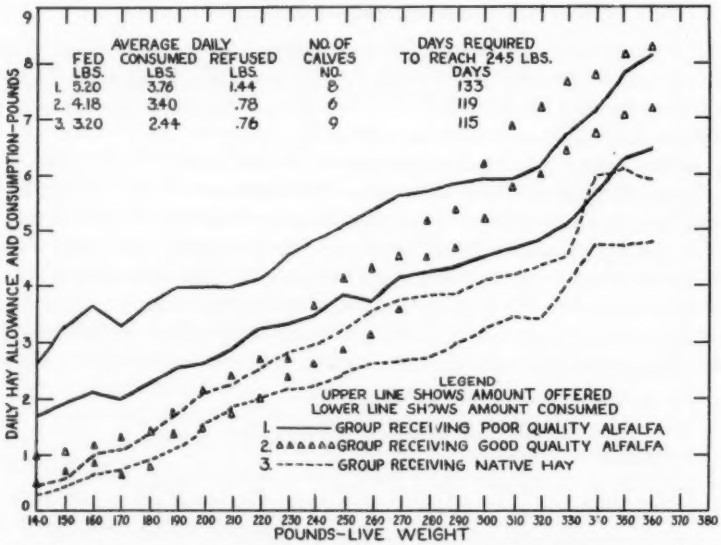

FIG. 1. Consumption of hay as affected by amounts offered to smaller calves.

These discrepancies are noticeable in figures 1 and 2, and again in figures 3 and 4. In figure 1, the calves receiving good quality alfalfa surged ahead of the other two groups in weight for age. Figures 2 and 4 show that after the calves passed 140 days of age, they were able to utilize more hay under the

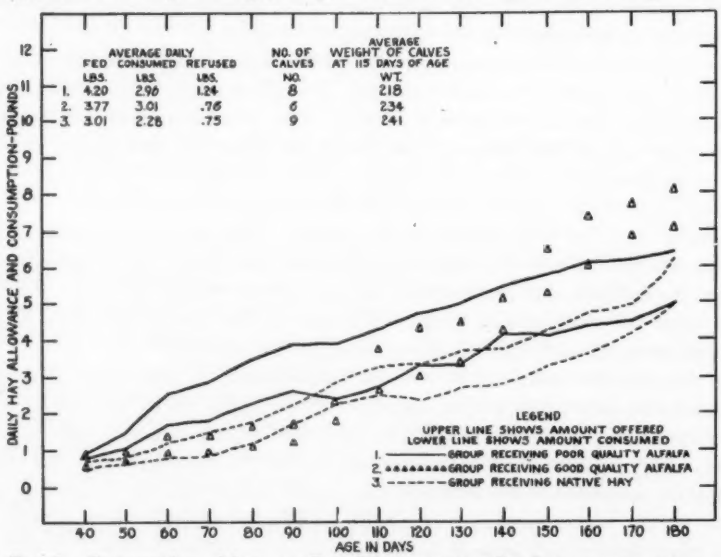

FIG. 2. Consumption of hay as affected by amounts offered to younger calves.

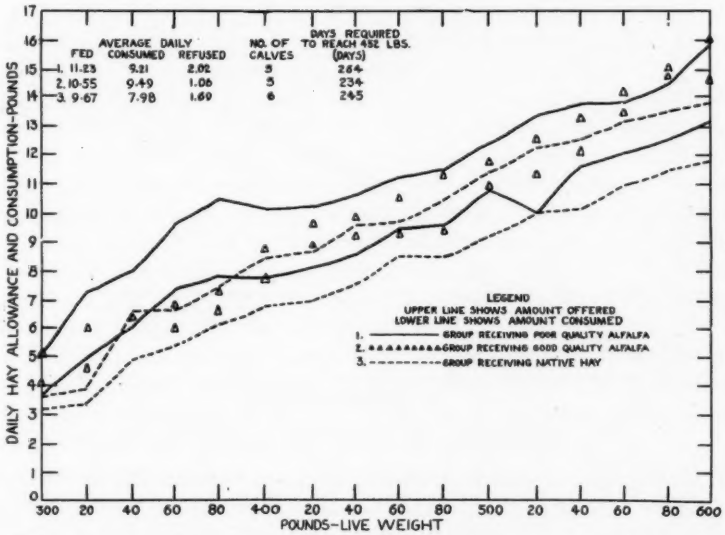

FIG. 3. Consumption of hay as affected by amounts offered to heavier calves.

ration provided for them, because of heavier weight for their age. At the same time, since the calves getting poorer quality hay were somewhat slower in reaching the 300 lb. level, and thus were somewhat older, the hay allowance was increased (fig. 3).

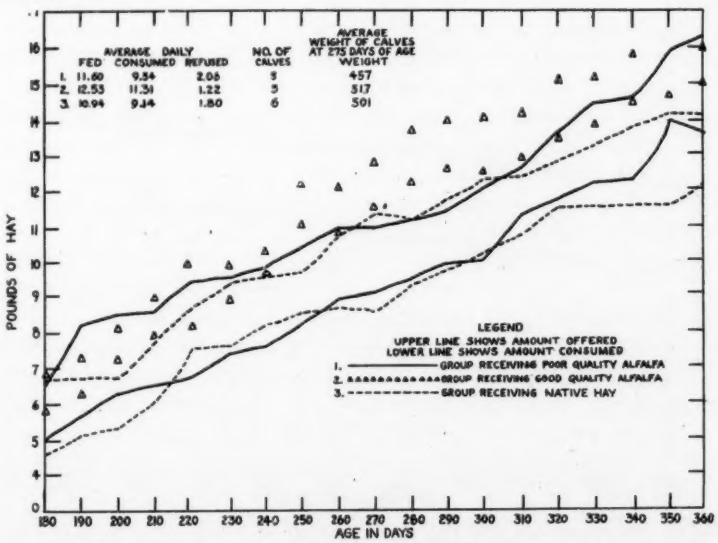

FIG. 4. Consumption of hay as affected by amounts offered to older calves.

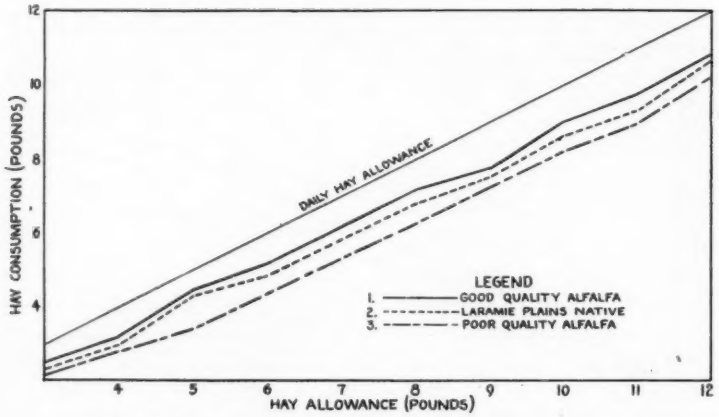

FIG. 5. Daily hay consumption of equal allowance basis.

All four figures, in general, illustrate the many variable factors which affect any measure of palatability. These factors are extremely difficult to control and to standardize. For example, it is theoretically possible to get three calves which will gain at an approximately equal rate. But if the calves are fed three different kinds of hay, all of equal feeding value but of varying palatability, the rate of gain in each of the calves will be affected by the palatability of the hay eaten, since the calf will reject more of the unpalatable hay. So, although

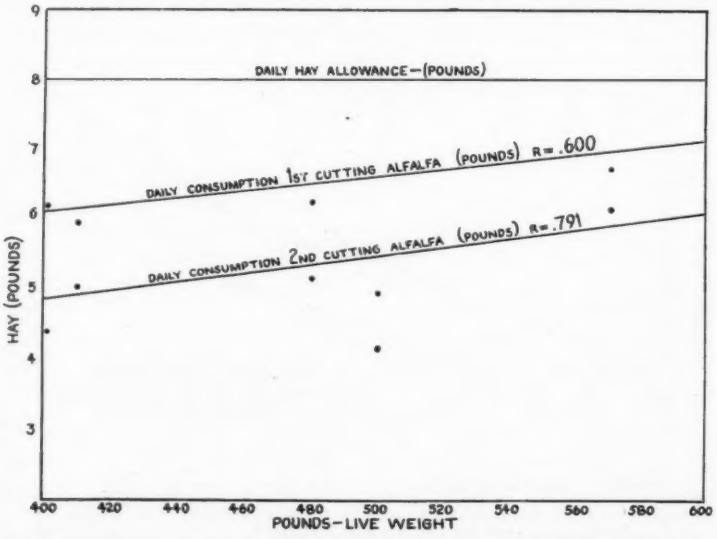
DAILY HAY ALLOWANCE—(POUNDS)
DAILY CONSUMPTION 1ST CUTTING ALFALFA (POUNDS) R=.600
DAILY CONSUMPTION 2ND CUTTING ALFALFA (POUNDS) R=.791
HAY (POUNDS)
POUNDS—LIVE WEIGHT

FIG. 6. Consumption of first and second cuttings of alfalfa, as affected by live weights of calves.

the three calves may start out on a relatively uniform basis, by the time they reach 6 months of age, they are no longer strictly comparable. The palatability results likewise are not strictly comparable.

Figures 1, 2, 3 and 4 give only a rough approximation of the palatability of the three different hays. The gap between the amount offered and the amount consumed suggests in a small degree whether or not the hay is palatable, but there is no real basis for comparison of the hays at any one point on the diagram.

Standardized amount of hay offered. Figure 5 compares the three hays entirely on a basis of how much hay was allowed and how much was rejected. The allowance for each calf was adjusted according to the animal's weight and age and took into consideration the amount of milk and grain which was given to the animal. This simply means that if the calf's ration required 7 lb. of hay in order to keep the ration up to the Morrison Standard for total digestible nutrients, the animal's other dietary needs theoretically were being satisfied, and its rejection or acceptance of the 7 lb. of hay would constitute about as accurate a measure of the hay's palatability as it would be possible to get.

The hay allowance here is a constant figure, while the variables of age and weight to some extent offset each other and are adjusted for in the ration which is fed to the calf. There are other variables which will be indicated in figure 6, but in general, with this procedure, where a fixed amount of hay is fed, one can expect a fairly uniform hay consumption from year to year. Thus, with a uniform and comparable consumption of hay set against a measured hay allowance, the rejection and consumption of the hay provide a fixed standard against which the palatability of any hay can be measured over a period of several years.

Using the consumption of each individual calf, the coefficient of variation of the consumption of these three hays at different hay allowances ranged from 1 to 3 per cent. The standard deviation ranged from 0.4 to 0.8 and the standard error between 0.05 and 0.2. The pooled variance was 0.37. The mean number of observations of daily consumptions for each hay allowance was 33, 22 and 38 for the good alfalfa, poor alfalfa and native hay, respectively. The mean number of calves for each of the above hays was 15, 8 and 11, respectively. The mean weight and age of the calves steadily increased with each raise in hay allowance, but varied 100 lb. in weight and 2 months in age within each grouping. The amount of grain consumed by the calves within each grouping varied as much as 2 lb. per head daily.

Other variable factors. There may be many factors other than hay allowances which should be controlled in hay palatability trials. From the available records in this experiment, there were indications of significant individual variations in hay consumption. There also is a progressive increase in hay consumption per lb. of live weight as the calf grows and as it becomes older.

To test this point more fully and also to determine the effect of live weight on consumption, both first and second cutting alfalfa hay were fed in equal quantities for 10 days to six calves of different weights. Figure 6 shows the result. For calves varying in weight from 400 to 600 lb., there was an upward

trend in consumption. The correlation between weight and consumption falls short of significance for such a small number of animals, but is statistically significant when the 500 lb. calf is eliminated. The 500 lb. calf apparently is the shy hay consumer in both instances. The results of the test indicate that one may well eliminate from palatability tests calves which are low hay consumers.

DISCUSSION

From the results of these experiments, certain rules can be formulated for determining relative palatability of hay for calves with the assurance of fairly uniform results year after year. The calves should be given a definite hay allowance according to age and weight. The data show that relative palatability of the three hays, when based upon consumption of the hay, depends upon the amount of hay offered. The relative palatability should be measured by consumption when equal amounts are fed. The error on repeated tests at different weights of calves was very small. By using this constant as a base (definite consumption of the same hay at definite allowance levels), one may not only compare the palatability of several types of hay grown during the same season but be assured of comparable results throughout many growing seasons. A feeding standard should be as a guide for determining the proper grain allowance. As shown by the small error in consumption in repeated tests, 1 or 2 lb. of grain, more or less, to make the ration conform to the Standard, makes little difference in hay consumption. Calves which are noticeably low hay consumers should be eliminated from palatability experiments.

Figure 5 shows clearly the difference in the relative palatability of the three hays and simplifies the confusion which exists in figures 1, 2, 3 and 4. The experimental error at any point along the consumption lines of each hay is very small, even though the calves varied in weight and age. The method of presentation used in figure 5 has the additional advantage of accumulating comparable data on the same chart over a period of years.

SUMMARY AND CONCLUSIONS

A study of the hay consumption of 34 Holstein calves from 3 to 12 months of age showed that consumption followed hay allowance over a wide range of weight and age. When the hay allowance was increased by 1 lb. daily, the coefficient of variation in consumption of three types of hay ranged from 1 to 3 per cent, the standard deviation ranged from 0.4 to 0.8, and the standard error between 0.5 and 0.2. Because of this small variation, hay palatability trials may be standardized to give comparable results over a period of several years by simply comparing hay consumption with a set hay allowance even though there may be a variation in weight for age and in grain consumption.

REFERENCES

(1) WILLARD, H. S., Factors Influencing the Palatability of Hay. Wyo. Agr. Expt. Sta. Bull. 199. 1933.

(2) WILLARD, H. S., Hay Consumption of Holstein Calves. J. Dairy Sci., 21 (3): 153–160. 1938.

TOTAL MILK PRODUCTION AS AFFECTED BY TIME OF MILKING AFTER APPLICATION OF A CONDITIONED STIMULUS[1]

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It generally is believed that the most efficient practical method of milking is stimulation of the udder and teats, followed shortly by rapid milking. Babcock (1) reported in 1889 the effect of milking the quarters of the udder one at a time in different order. The quarters milked second produced the greatest amount, and the production of quarters milked first, third and fourth were in descending order. Experiments of a similar design which essentially substantiated the results obtained by Babcock later were conducted by Beach (2), Emery (8) and Plumb (12). Bitting (3) and Miller and Petersen (10) repeated Babcock's work, but found that milk production decreased from the first to the fourth quarter milked. Babcock (1), Crowther (4) and Skrodel (13) demonstrated reduced milk production when the milking act was prolonged unduly. Miller and Petersen (10) also obtained a reduced milk flow by stimulation of cows 20 minutes before milking. Dahlberg (5) stated that reduction of milking time from about 10 minutes to 4 or 5 minutes resulted in greater annual production. However, Dodd and Foot (6) obtained a slight reduction in total milk yield by reducing the milking time from a mean of 8 to 5 minutes. Knodt *et al.* (9) found no significant differences in total milk production of cows milked at intervals of 2, 4, 6, 8 and 10 minutes after preparation for periods of 35 and 70 days, nor in another experiment of 90 days where the cows were milked at 2, 5, 10 and 20 minutes after preparation.

Ely and Petersen (7) state that the expulsion of milk from the alveoli into the ducts is brought about by the action of a posterior pituitary factor (or factors) which is discharged as the result of conditioned stimuli which precede or the mechanical stimulations which accompany milking, or both. According to Pavlov (11), a reflex can be conditioned by the close association of a heretofore neutral stimulus to an established reflex. Where varying amounts of time are allowed to elapse between the conditioned stimulus and the subsequent unconditioned stimulus, the conditioned reflex is known as a delayed reflex. If a conditioned reflex is to be kept at a constant strength, the conditioned and unconditioned stimuli must be applied regularly or the conditioned reflex gradually weakens and becomes extinct. Delayed reflexes become extinct more readily than simultaneous reflexes. In the modern methods of milking, where the udder is washed and massaged shortly before the attachment of the teat cups, the heretofore neutral stimuli, *i.e.*, hot water and massage, become conditioned stimuli.

The object of these investigations was to ascertain the duration of effectiveness

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TABLE 1

Effect on total milk production of milking at various intervals after stimulation

No. of cow	296				310				311				359				874			
Half of udder	Right		Left		Right		Left		Right		Left		Right		Left		Right		Left	
Period	T.A.S.[a]	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk	T.A.S.	Milk
	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)	(*min.*)	(*lb.*)
Preliminary	2	7.5	2	6.6	2	12.1	2	11.8	2	9.6	2	8.7	2	13.2	2	13.5	2	11.5	2	10.7
I	2	7.2	8	6.1	2	11.8	4	12.0	2	8.9	12	7.4	2	12.6	16	9.4	2	11.3	20	9.3
II	16	6.6	2	6.3	12	8.5	2	11.5	20	8.1	2	8.1	4	12.4	2	10.8	8	11.3	2	9.8
III	2	6.8	12	5.4	2	10.1	8	9.2	2	7.9	16	6.8	2	11.5	20	7.4	2	10.8	4	9.4
IV	20	5.9	2	5.5	16	7.7	2	10.2	4	7.7	2	7.1	8	10.7	2	9.2	12	9.6	2	8.9
V	2	6.4	4	5.3	2	8.8	20	6.0	2	7.6	8	6.4	2	10.6	12	6.5	2	10.3	16	7.6
Post	2	6.3	2	5.3	2	9.3	2	8.9	2	7.2	2	6.7	2	10.4	2	7.4	2	10.3	2	8.0

[a] T.A.S. = Time after stimulation.

of a conditioned stimulation, *i.e.*, a hot water wash and massage of the udder and teats, on the discharge of milk from the mammary gland.

EXPERIMENTAL PROCEDURE

Five cows, four Holsteins and one Brown Swiss, were selected with as much variation in production and stage of lactation as possible. The mean production of each half of the udder was determined during a 10-day preliminary period by milking each half of the udder simultaneously into a separate container. Each cow in the experiment had been conditioned to a hot water wash and massage several minutes before milking since the beginning of their respective lactation periods. During the preliminary period, the cows were prepared for milking by a hot water wash and massage, and the milkers were attached 2 minutes after this stimulation. The cows were prepared in the same manner during the experimental periods. However, during the experimental periods, one half of the udder, which served as a control, was milked at 2 and the other half at 4, 8, 12, 16 or 20 minutes after stimulation. One half of the udder alternately served as control and experimental. The experiment was of Latin Square design. Within an experimental period, each of the five treatments was assigned to a different cow, and in the course of the five experimental periods each cow was subjected to every treatment. Treatments were at random. The experimental periods were of 5-day duration, followed by a 2-day transition period. The final experimental period was followed by a 5-day post-experimental period.

The basis for evaluating the effect of the treatments was the average production of the cows milked after 2-minute intervals immediately preceding and following an experimental period. This measure took into consideration the decline in lactation.

RESULTS

The production of the cows during the period of experimentation and the design of the experiment are presented in table 1. Each half of the udder served as its own control. The analysis of variance of the data is presented in table 2. The least significant difference at the 1 per cent level was found to be 6.50 lb. of milk for the treatment total. Consequently, the decrease in milk production,

TABLE 2

Differences in average milk production of experimental and control periods

Cows	Differences in average milk production as compared to average base production when milking followed stimulation by:				
	4 min.	8 min.	12 min.	16 min.	20 min.
	(*lb.*)	(*lb.*)	(*lb.*)	(*lb.*)	(*lb.*)
296	−0.10	−0.35	−0.50	−0.40	−0.70
310	+0.35	−1.65	−2.45	−1.75	−3.55
311	−0.05	−0.50	−1.00	−0.80	−0.30
359	+0.35	−0.35	−1.80	−2.75	−2.60
874	+0.05	+0.25	−0.95	−0.85	−0.95
Total	+0.60	−2.60	−6.70[a]	6.55[a]	8.10[a]

[a] Significant at the 1 per cent level.

when the cows were milked at 12, 16 and 20 minutes after stimulation, was highly significant. The differences in production obtained by milking at 2, 4 and 8 minutes after stimulation were not significant. The decrease in production which occurred at the 8 minute interval was not significant with the numbers involved.

DISCUSSION

The time required to milk cows a quarter at a time was not given by Babcock (1), Beach (2), Bitting (3), Emery (8) and Plumb (12), but Miller and Petersen (10) state that about 15 and 20 minutes elapsed before the milking of the third and fourth quarters, respectively. A statistical analysis of Babcock's data shows no significant difference in production for the first three quarters milked. Our results confirm the findings of Miller and Petersen (10). However, our results are not in agreement with the work reported by Knodt *et al.* (9). This discrepancy may be explained by their cows becoming unconditioned to the stimulation because of too long an interval between the application of the conditioned stimulation and the unconditioned reflex over periods of 35, 70 and 90 days. The failure of Dodd and Foot (6) to obtain a definite increase in production by decreasing the milking time is consistent with the results of this experiment, because the mean time of their milking period at the start was only a little over 8 minutes. Furthermore, the purpose of their experiment was to train cows for more rapid milking, and at times the cows were not completely milked out. They obtained a lower fat test which perhaps was a result of incomplete milking.

Four of the five cows showed a decrease in production when milking began 8 minutes after stimulation had been applied. Although statistical analyses of these data show this decrease in production to be insignificant, the decrease indicates that 8 minutes is near the threshold level. The results of these experiments would indicate that in general practice, milking should begin before 8 minutes have elapsed after a cow has been stimulated to discharge her milk if maximum production is to be obtained.

SUMMARY

An experiment was conducted to determine whether there was any difference in production when cows were milked at 4, 8, 12, 16 and 20 minutes after a conditioned stimulation, as compared with 2 minutes after stimulation.

There was a highly significant decrease in production when cows were milked 12 or more minutes after a conditioned stimulation.

The authors express their appreciation to Dr. J. E. Torrie for the advice given in the planning of this experiment and the statistical analyses of these data.

REFERENCES

(1) Babcock, S. M. Variations in the yield and quality of milk. Sixth Annual Rept. Wis. Agr. Expt. Sta., pp. 42–62. 1889.

(2) Beach, C. L. The yield of quarters on same side of udder. Conn. (Storrs) Agr. Expt. Sta. Rept., pp. 135–137. 1904.

(3) BITTING, A. W. The physiology of milk secretion. 14th Annual Rept. Ind. Agr. Expt. Sta., pp. 51–88. 1901.

(4) CROWTHER, C. The significance of the act of milking. Brit. Assoc. Advancement Sci. Rept. 85th Mtg., pp. 779–780. 1915.

(5) DAHLBERG, A. C. The influence on milk production of a definite time interval for milking cows by machine. N. Y. State Agr. Expt. Sta. Bull. 697. 1941.

(6) DODD, F. H., AND FOOT, A. S. Experiments on milking technique. 1. Effect of washing the udder with hot water. 2. Effect of reducing milking time. J. Dairy Research, **15**: 1–17. 1947.

(7) ELY, F., AND PETERSEN, W. E. Factors involved in the ejection of milk. J. Dairy Sci., **24**: 211–224. 1941.

(8) EMERY, F. E. Milk records and tests. N. C. Agr. Expt. Sta. Bull. 116. 1895.

(9) KNODT, C. B., REID, J. J., WILLIAMS, P. S., AND KESLER, E. M. The effect of the interval between washing of the udder and attachment of milking machines upon the bacterial flora and milk production of dairy cows. J. Dairy Sci., **30**: 580–581. 1947.

(10) MILLER, K., AND PETERSEN, W. E. Some factors involved in efficient milking. J. Dairy Sci., **24**: 225–238. 1941.

(11) PAVLOV, I. P. Lectures on conditional reflexes. Translation by Gnatt and Volbroth. International Publishers, New York. 1928.

(12) PLUMB, C. S. The udder of the cow. Ind. Agr. Expt. Sta. Bull. 62. 1896.

(13) SKRODEL, L. Der Einfluss der Milchgeschwindigkeit auf die Sekretion der Milch und des Milchfettes. Milch. Forsch., **19**: 95–105. 1937.

EFFECT OF LACTATION AND RATION ON THE FAT AND VITAMIN A LEVEL OF SOW'S MILK[1]

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The composition of sow's milk has been studied less than that of milk of the other domestic animals. Several studies have been reported on the fat and vitamin A content of sow's milk, but most of these have been quite limited in scope. Reports from the Wisconsin Agricultural Experiment Station as early as 1897 stated that the fat content of normal milk from sows averaged 7.06 per cent. This study by Henry and Woll (9) was on only seven samples of milk. Later Woll (17) reported a mean fat percentage of 5.97 for five samples of sow's milk. Davies (6), in reporting on the composition of milk from various species of mammals, gave values ranging from 4.55 to 9.54 per cent fat for porcine milk.

Hughes and Hart (10) reviewed the early literature on the gross composition of sow's milk. From the data of other workers, they calculated combined results of 6.9 per cent fat. In their own work with two sows, they obtained a mean value of 5.3 per cent fat for normal milk and 5.1 per cent fat for colostrum.

Willett and Maruyama (16) reported that the percentage of fat in sow's milk increased with the fat content of the ration. The average percentage of fat in the milk of sows on dry concentrates only was 6.1, and for sows on garbage only was 9.6 per cent. They also observed an increase in fat content of the milk with an advance in the stage of lactation. Braude *et al.* (4) showed conversely that after the rapid change from colostrum to milk, the fat content decreased appreciably as the lactation advanced.

Mean values for 18 samples of sow's colostrum of 3.4 per cent fat and 347 I.U. of vitamin A per 100 ml. of colostrum are reported by Braude *et al.* (5). In a later paper (4), they reported the following values for colostrum: 4.05 ± 0.43 g. of fat per 100 g. of milk, and 71.1 ± 9.1 I.U. vitamin A per g. fat; and for normal milk: 8.17 ± 0.17 g. fat per 100 g. of milk, and 11.0 ± 0.4 I.U. vitamin A per g. fat.

The study reported by Braude *et al.* (4) is the only work in the literature where the vitamin A content of the milk is calculated on the basis of the fat rather than the total milk volume. However, several other workers have reported on the vitamin A content of sow's milk. Benham (1) found that the vitamin A content of sow's colostrum ranged from 131 to 254 I.U. per 100 ml. on the first day. Work reported by Schofield *et al.* (12) showed that giving sows large doses of vitamin A late in pregnancy increased the concentration of this vitamin in the colostrum.

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EXPERIMENTAL PROCEDURE

The data presented in this paper are the results of analyses for fat and vitamin A levels of the milk from ten sows carried through gestation on pasture, and ten sows carried through gestation in dry lot. The sows on pasture were self-fed a grain ration supplemented with animal protein, while those in dry lot were self-fed a grain ration supplemented with plant protein and 5 per cent alfalfa meal. The sows on pasture were five Poland Chinas and five Chester Whites, while all those in dry lot were Poland Chinas. All sows were in their

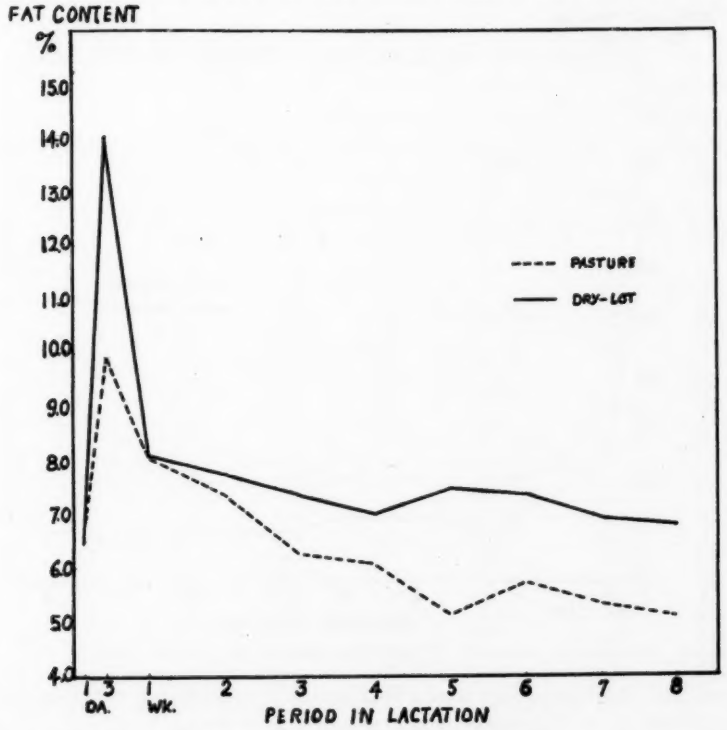

FIG. 1. The fat content of milk from pasture and dry-lot sows.

first or second lactation period. The farrowing dates of the sows in the pasture group ranged between September 24 and October 11, 1947, and the sows in the dry-lot group farrowed between November 12 and December 26, 1947. They weaned an average of 7.1 and 4.8 pigs, respectively.

The sows were milked on the day of parturition as soon after farrowing as possible, then on the third day and at the end of the first week and each subsequent week thereafter until weaning the litters at 8 weeks of age. The let-down of milk was induced by the injection of Pitocin (Parke, Davis and Co.) as described by Bowland *et al.* (2) and first used in cows by Ely and Petersen (7).

The determination of vitamin A in the 201 samples was run according to a slight modification of the method of Boyer *et al.* (3). The 195 fat determinations were made with the use of the Minnesota Babcock reagent. Eleven samples were run by the official Mojonnier Fat Extraction method to check on the accuracy of the Minnesota Babcock method. In all 11 cases, the Mojonnier method gave higher readings than the Minnesota Babcock method, the mean difference being 0.69 per cent fat. Because of this consistent difference, a logical inference might be that sow's milk contained a high phospholipid con-

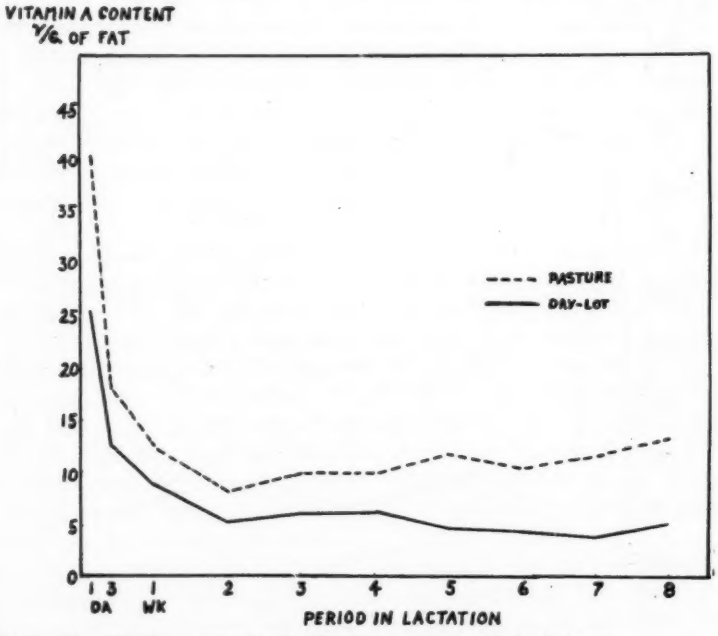

FIG. 2. The vitamin A content of milk from pasture and dry-lot sows.

tent, as the ether extraction would remove the phospholipids, whereas the Minnesota Babcock reagent would not.

RESULTS

The mean results of the fat determinations throughout lactation are shown in figure 1, and results of the vitamin A determinations calculated on the basis of fat are shown in figure 2. The average fat and vitamin A content in the colostrum and normal milk of each individual sow on experiment is shown in table 1.

The fat content of the normal milk from the dry-lot sows was consistently higher than that from pasture sows. However, in the case of first-day colostrum, the colostrum of the pasture sows had an average fat content of 6.73 per cent

and that of the dry-lot sows 6.45 per cent. Very probably this lower fat content of milk from sows previously on pasture was because of an increased volume of milk produced, as they weaned more pigs than the dry-lot group.

No breed difference was noted in the pasture sows where both Chester White and Poland China breeds were on experiment. The average fat content of the normal milk was 6.07 per cent for Chester Whites, and 6.17 per cent for Poland Chinas. There was no difference in lactational trend between the two breeds. The milk of both breeds in the pasture group, as well as the dry-lot group,

TABLE 1

The mean fat and vitamin A content of the milk of individual sows

Group	Breed	Fat content			Vitamin A content		
		Colostrum		Normal milk	Colostrum		Normal milk
		1st day	3rd day	Av. 1–8 wk.	1st day	3rd day	Av. 1–8 wk.
		(%)	(%)	(%)	(γ/g. of fat)	(γ/g. of fat)	(γ/g. of fat)
Pasture	C.W.	8.1	10.9	5.07	22.71	6.24	12.19
	C.W.	6.8	9.6	5.35	18.94	15.86	11.49
	C.W.	7.1	12.8	6.10	18.98	12.60	12.33
	C.W.	7.2	7.9	6.34	22.22	47.20	13.35
	C.W.	9.5	10.0	7.49	21.93	8.32	8.90
	P.C.	6.7	8.8	5.50	10.75	21.47	12.63
	P.C.	4.9	.....	5.73	36.53	.....	10.49
	P.C.	1.4	12.5	6.09	201.66	18.07	9.46
	P.C.	8.9	.....	6.75	9.82	.....	8.14
	P.C.	.....	7.5	6.78	.....	15.30	10.36
	Av.	6.73	9.99	6.12	40.23	18.13	10.93
Dry-lot	P.C.	7.1	11.3	6.15	20.38	18.09	6.46
	P.C.	4.7	11.5	6.79	27.13	29.08	6.69
	P.C.	7.4	13.5	6.90	12.53	8.93	6.29
	P.C.	5.0	11.0	6.95	34.96	10.75	5.22
	P.C.	4.1	8.4	7.01	42.98	14.07	5.04
	P.C.	10.9	19.8	7.45	10.95	9.91	4.65
	P.C.	5.0	15.6	7.54	36.93	6.28	6.08
	P.C.	7.4	15.7	8.39	15.97	8.10	4.57
	P.C.	9.4	16.4	8.58	18.46	10.00	4.83
	P.C.	3.5	17.2	8.73	33.77	10.25	7.02
	Av.	6.45	14.04	7.45	25.41	12.55	5.69

showed a tendency to decline in fat content as lactation advanced up to weaning at 8 weeks of age. This observation agrees with Braude *et al.* (4) but disagrees with Willett and Maruyama (16).

The milk fat from the pasture sows showed a considerably higher concentration of vitamin A than the milk fat from dry-lot sows. This difference was wider when calculated on the basis of fat than on the basis of volume of milk because of the inverse relation of the fat content of the milk in the two groups. As lactation advanced the spread between the vitamin A concentration of the milk from the two groups became wider as shown in figure 2.

The vitamin A concentration in the fat was down in the range of normal milk, namely 12.51 γ per g. of fat for pasture sows and 8.94 γ per g. of fat for dry-lot sows at the end of the first week of lactation. The vitamin A content of normal milk fat was about one fifth of that in the colostral fat in the dry-lot sows, and one quarter in the pasture sows. There was a rapid drop in vitamin A the first 3 days of lactation, from 25.41 to 12.55 γ per g. fat in the dry-lot sows, and from 40.23 to 18.13 γ per g. fat in the pasture sows. Except for one sow in the pasture group, the first day vitamin A did not vary appreciably between the two groups. The drop in vitamin A concentration in the first 3 days did not show up when the vitamin A was reported on the basis of 100 ml. of milk as shown by Bowland *et al.* (2). However, the sudden unexplained rapid increase in fat in these first 3 days caused the concentration of vitamin A per g. of fat to be lowered.

The vitamin A content of the fat in the milk of the pasture group showed a gradual increase in advanced lactation, whereas the dry-lot group tended to decline. There generally was about a three- to fourfold variation in the vitamin A content in the colostrum and normal milk within groups.

DISCUSSION

The fat content of colostral milk obtained in these studies was considerably higher than the values of 4.05 and 3.4 per cent reported by Braude *et al.* (4, 5), respectively. No definite change could be noted between the fat content of colostrum obtained before the pigs suckled and that obtained shortly afterward. There are no reports in the literature of high values similar to those obtained in this work for fat content of colostrum on the third day of lactation. Braude *et al.* (4) showed a very rapid rise in the first few days but not to the same extent.

The milk fat values of 7.45 and 6.12 per cent for dry-lot and pasture sows, respectively, were lower than the values obtained by Braude *et al.* (4) but similar to the combined calculated values of other workers reported by Hughes and Hart (10). This variation would be expected, as the fat content of sow's milk seemed to be influenced very easily as illustrated by Willett and Maruyama (16), who obtained a rise from 6.1 to 9.6 per cent fat by feeding a high-fat diet. Reece (11) reported that factors known to influence variation in fat content of cow's milk are breed and individuality of the cow, state of lactation, season of the year, feed, age of animal, day to day variation, time of milking, frequency of milking and the first-and last-drawn milk. In this work, individuality of the sow, stage of lactation and feed have been shown to have an effect on the fat content of sow's milk. The animals were milked as completely as possible to try to prevent any variation because of first- and last-drawn milk. In this case, no breed difference was obtained between Poland China and Chester White milk. However, other factors mentioned by Reece, as well as methods of analysis, might cause a variation between results of different workers. The decrease in fat percentage of sow's milk as lactation advanced was the opposite trend to that shown by cow's milk. This may indicate that milk production remains at a high level

in sows for the 8 weeks lactation period. As lactation in sows is stopped suddenly by weaning the litter, it is not entirely comparable with lactation in cows.

The vitamin A level of sow's milk fat in changing from colostrum to milk followed the same general trend as in other species, namely, decreasing fairly rapidly. In sows the level of vitamin A in colostrum was only 4 to 5 times as high as in normal milk. This is much different from the colostrum of cattle, where the vitamin A content of normal milk is one twentieth or less of the initial concentration of vitamin A in colostrum, as reported by Stewart and McCallum (14) and Hansen *et al.* (8).

As lactation advanced, the spread between the vitamin A content of the milk fat in the pasture sows and dry-lot sows became wider. A depletion of the stored vitamin A in the dry-lot sows could account for the gradual decrease of vitamin A in their milk, whereas it tended to rise as lactation advanced in sows carried through gestation on pasture. There was no correlation between the number of pigs weaned or the weight of the litters weaned with the fat or vitamin A content of the milk within groups.

Shaw (12) has reported that injection of oxytocin in cows caused no significant differences in production of milk and milk fat over a 9-day period. Smith (13) found an increase in fat content for the first milking when oxytocin was injected. From this it may be assumed that the milk obtained from sows injected with oxytocin is approximately normal, although it might be slightly high in fat. The sampling error involved in milking by this method is much smaller than by attempting to get milk by hand without oxytocin, as complete evacuation of the mammary gland in sows cannot be obtained without the injection of oxytocin.

SUMMARY AND CONCLUSIONS

1. The fat and vitamin A levels of colostrum and milk are reported for the entire lactational period for ten sows carried through growth and gestation on pasture, and ten sows carried through growth and gestation in dry lot.

2. A gradual decline in fat content of the milk as lactation advanced was indicated in both groups.

3. An increase in vitamin A content of the milk fat toward the end of lactation was evident in the pasture sows, but a reverse trend occurred in the dry-lot sows. The mean values for fat were: first-day colostrum from pasture sows 6.73 per cent, from dry-lot sows 6.45 per cent; normal milk from pasture sows 6.12 per cent, from dry-lot sows 7.45 per cent of the milk. The mean values for vitamin A were: first-day colostrum from pasture sows 40.23 γ per g. of fat, from dry-lot sows 25.41 γ per g. of fat; normal milk from pasture sows 10.93 γ per g. fat, from dry-lot sows 5.69 γ per g. of fat.

4. No breed difference in fat content of the milk or vitamin A content of the fat was apparent between Chester White and Poland China sows.

REFERENCES

(1) BENHAM, G. H. Vitamin A and New-born Pigs. Can. J. Comp. Med., 7 (10): 291–297. 1943.

(2) BOWLAND, J. P., GRUMMER, R. H., PHILLIPS, P. H., AND BOHSTEDT, G. The Vitamin A and Vitamin C Content of Sow's Colostrum and Milk. J. Animal Sci. In press. 1948.

(3) BOYER, P. D., SPITZER, R., JENSEN, C., AND PHILLIPS, P. H. Determination of Vitamin A and Carotene in Milk. A Rapid Extraction Procedure. Ind. Eng. Chem., Ann. Ed., 16: 101–102. 1944.

(4) BRAUDE, R., COATES, M. E., HENRY, K. M., KON, S. K., ROWLAND, S. J., THOMPSON, S. Y., AND WALKER, D. M. A Study of the Composition of Sow's Milk. Brit. J. Nutrition 1 (1): 64–77. 1947.

(5) BRAUDE, R., KON, S. K., AND THOMPSON, S. Y. A Note on Certain Vitamins of Sow's Colostrum. J. Dairy Research, 14 (3): 414–419. 1946.

(6) DAVIES, W. L. The Chemistry of Milk. 534 Pp. Chapman and Hall, Ltd., London. 1939.

(7) ELY, F., AND PETERSEN, W. E. Factors Involved in the Ejection of Milk. J. Dairy Sci., 24: 211–223. 1941.

(8) HANSEN, R. G., PHILLIPS, P. H., AND SMITH, V. R. Colostrum Milk and Its Vitamin A Content. J. Dairy Sci., 29 (12): 809–814. 1946.

(9) HENRY, W. A., AND WOLL, F. W. On the Yield and Composition of Sow's Milk. W'is. Expt. Sta. Rept., p. 10. 1897.

(10) HUGHES, E. H., AND HART, G. H. Production and Composition of Sow's Milk. J. Nutrition, 9: 311–322. 1935.

(11) REECE, R. P. Factors that Affect the Fat Content of Milk. N. J. State College Agr. Ext. Bull. 238. 1943.

(12) SCHOFIELD, F. W., INGLE, R. T., AND MCFARLANE, D. W. Vitamin A Assays of the Milk of Nursing Sows. Rept. Ontario Vet. College for 1941, Pp. 16–19. 1942.

(13) SHAW, J. C. The Effect of Oxytocin on Milk and Milk Fat Secretion. J. Dairy Sci., 25 (12): 1051–1055. 1942.

(14) SMITH, V. R. The Effect of Milking at Short Intervals With and Without Injections of Oxytocin. J. Dairy Sci., 30 (9): 703–715. 1947.

(15) STEWART, J., AND MCCALLUM, J. W. "White Scour" in Calves and Related Infections. 1. The Significance of Vitamin A Content of the Colostrum as a Predisposing Factor in the Causation of Such Conditions. J. Comp. Path., 51: 290–295. 1938.

(16) WILLETT, E. L., AND MARUYAMA, C. The Effect of Intake of Garbage Fat upon Fat Content of Sow's Milk. J. Animal Sci., 5: 365–370. 1946.

(17) WOLL, F. W. The Composition of Sow's Milk. Wis. Expt. Sta. Rept. P. 267. 1899.

THE VIABILITY OF BRUCELLA ABORTUS IN MILK AND IN CREAM DURING HEAT TREATMENT IN ELECTRICALLY OPERATED HOME PASTEURIZERS[1]

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The presence of *Brucella abortus*, or the possibility of its presence in milk and cream coming from herds of dairy cattle which contain animals infected with the *Brucella* organism (Bang's disease), is an additional reason for the pasteurization of milk and cream destined for human consumption. The ingestion of *Brucella* infective dairy products is known to be one of the chief modes of transmitting brucellosis (undulant fever) to humans. While a large percentage of the milk and cream that is being distributed in the United States through commercial channels is pasteurized and, as a consequence, is free from living *Brucella* organisms, this cannot be said of a large amount of dairy products produced and used by farm families. In order to break one of the links in the infection chain of the *Brucella* organism where it is present in animals on a farm, it is essential that milk and cream consumed on such a farm be pasteurized.

The recent development of small, economical and easy-to-operate electric pasteurizers has brought to the farmer a means of not only treating milk and cream to preserve their keeping qualities, but to render these dairy products free from pathogenic bacteria.

Certain types of home electric pasteurizers have been studied by Trout and Bortree (2) to determine their ease and time of operation, the destruction of contaminating bacteria and the effect upon the milk itself. It was shown in this study that three types of pasteurizers, if operated according to the directions of the manufacturers, reduced the initial number of bacteria present in milk 82 to 99 per cent, depending upon the number and type initially present. The flavor of the milk or its creaming property was not impaired appreciably by the treatment.

From the data obtained by Trout and Bortree (2), there was no indication that *Brucella* organisms would not be killed if present in milk and cream during heat treatment in the electric pasteurizers. It seemed desirable, however, to have available specific information on this point, especially on cream of different butterfat concentrations, since most of the *Brucella* organisms are concentrated in cream during its separation from whole milk.

EXPERIMENTAL PROCEDURE

Two of the types of electric pasteurizers used by Trout and Bortree (2) were selected for this study, as they represented extreme differences in construction and operation. One is known as the Waters Conley pail type and the

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TABLE 1

Time and temperature required to kill all Br. abortus in whole milk, using pail-type electric pasteurizer (3000 ml. sample)

Heating time	Recorded temperature	*Br. abortus* colony count
(*min.*)	(° *C.*)	(*1000's/ml.*)
0	19	127.0
10	31	122.5
15	39	128.2
20	46	101.5
25	54	121.2
30	61	12.2
40	68	0
50	68	0
70	69	0

All *Brucella* killed within 10 min. in effective temperature range.

other as the Wright in-the-bottle type. Their construction and method of operation have been described by Schaenzer and Shiozawa (1).

In order to determine as closely as possible the efficacy of the two machines for killing *Br. abortus* during the time of operation, measured amounts of commercially pasteurized milk and cream were inoculated with a standardized suspension of a laboratory strain of *Br. abortus*. Raw milk and raw cream could not be used in the study, as they contained too large a number of contaminating bacteria, the presence of which made it difficult to make an accurate plate count of the inoculated *Brucella* organisms during the initial period of treatment.

The volume of milk or cream used for inoculation and heat treatment was 1 l. for the bottle type and 1.5 to 3 l. for the pail type of pasteurizer. Approximately 100,000 live organisms in suspension (plate colony count) were added for each milliliter of liquid. To insure thorough distribution of the organisms, the inoculated samples were stirred with a mechanical stirrer for 15 minutes before heat treatment. Samples of milk or cream were collected from the containers and diluted 1:100 in sterile diluting liquid in order to estimate the number of viable organisms present before heat treatment and the number remaining at 2, 5 or 10 minute intervals during the period of heat treatment.

TABLE 2

Time and temperature required to kill all Br. abortus in 20 per cent cream, using pail-type, electric pasteurizer (1500 ml. sample)

Heating time	Recorded temperature	*Br. abortus* colony count
(*min.*)	(° *C.*)	(*1000's/ml.*)
0	36	115.0
10	55	100.0
12	64	40.0
15	70	0
20	71	0
30	69	0
40	72	0
50	69	0

All *Brucella* killed within 6 min. in effective temperature range.

TABLE 3

Time and temperature required to kill all Br. abortus in 40 per cent cream, using pail-type electric pasteurizer (2000 ml. sample)

Heating time	Recorded temperature	*Br. abortus* colony count
(*min.*)	(° *C.*)	(*1000's/ml.*)
0	36	77.5
10	53	81.5
13	60	63.0
15	63	0
20	67	0
30	67	0
40	68	0
50	71	0

All *Brucella* killed within 5 min. in effective temperature range.

Plate counts were made on crystal violet tryptose agar using 1 ml. of the 1:100 dilution.

RESULTS

The electric timing control on both machines was set to begin operating when the temperature of the liquids reached 60–61° C. The electric heat control circuit on the pail type was broken automatically 40 minutes after a killing temperature was reached, and the one on the bottle type 30 minutes later.

In tables 1, 2 and 3 are recorded the results of the experiments obtained with the Waters Conley pail type pasteurizer. The length of time that was required for this pasteurizer to kill all the *Brucella* organisms added to milk or cream after reaching 60° C. varied from 5 to 10 minutes. The maximum temperatures recorded toward the end of the treatment period varied from 69 to 72° C. These experiments were performed three times with approximately the same results.

The results obtained with the Wright in-the-bottle pasteurizer are set forth in tables 4, 5 and 6. The length of time that was required for this type of pasteurizer to kill all added *Br. abortus* organisms after reaching an effective temperature (60° C.) varied from 5 to 8 minutes. The maximum temperature recorded toward the end of the treatment period was 64° C. Similar results were obtained in two additional experiments on inoculated milk and cream.

TABLE 4

Time and temperature required to kill all Br. abortus in whole milk, using bottle-type electric pasteurizer (1000 ml. sample)

Heating time	Recorded temperature	*Br. abortus* colony count
(*min.*)	(° *C.*)	(*1000's/ml.*)
0	—	119.5
30	45	100.7
52	60	35.5
54	59	27.5
56	61	2.8
58	62	0.1
60	62	0
64	62	0
84	64	0

All *Brucella* killed within 8 min. in effective temperature range.

TABLE 5

Time and temperature required to kill Br. abortus in 20 per cent cream, using bottle-type electric pasteurizer (1000 ml. sample)

Heating time	Recorded temperature	*Br. abortus* colony count
(*min.*)	(° *C.*)	(*1000's/ml.*)
0	25	122.5
15	34	94.0
20	38	94.0
25	41	97.5
30	45	90.0
35	49	87.5
40	53	77.2
45	56	79.5
50	60	7.7
55	62	0
60	63	0
80	64	0

All *Brucella* killed within 5 min. in effective temperature range.

TABLE 6

Time and temperature required to kill all Br. abortus in 40 per cent cream, using bottle-type electric pasteurizer (1000 ml. sample)

Heating time	Recorded temperature	*Br. abortus* colony count
(*min.*)	(° *C.*)	(*1000's/ml.*)
0	25	107.5
15	34	155.0
20	38	87.5
25	41	111.5
30	45	112.5
35	49	87.5
40	53	85.7
45	56	87.5
50	60	30.5
55	62	0
60	63	0
80	64	0

All *Brucella* killed within 5 min. in effective temperature range.

In view of the fact that heat killing temperatures were maintained for 25–30 minutes after live *Brucella* organisms could not be detected in 1 ml. amounts of either milk or cream, it would appear that a wide operating safety factor is provided by both types of pasteurizers.

SUMMARY

The data show that when milk or cream is inoculated with approximately 100,000 *Brucella abortus* organisms per ml. and treated in two different electrically operated milk pasteurizers for home use, according to the directions of the manufacturers, all *Brucella* organisms are killed within 5 to 10 minutes after the thermo-regulator begins to control the pre-set operating temperatures.

REFERENCES

(1) Schaenzer, J. P., and Shiozawa, S. Electric Milk Pasteurizers for Farm Dairies. Conv. Am. Soc. Agr. Engrs. Chicago. (Mimeo.) 11 pp. 1946.

(2) Trout, G. M., and Bortree, A. L. Laboratory Pasteurization Studies on Home Electric Milk Pasteurizers. Mich. Agr. Expt. Sta. Quart. Bull. 30 (1): 64–69. 1947.

DETERMINATION OF CAROTENE IN SILAGE[1]

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Since most of the carotene of the vegetative tissue of plants is found in the leaves, it is obvious that a heterogenous material such as silage will be difficult to sample for analytical purposes. In present methods, there are inadequate provisions for overcoming this difficulty. The method which has been used in this laboratory is a modification of the Peterson *et al.* method (2). The determinations usually were made in triplicate, with samples of 20 g. or more each, to reduce as much as possible the effect of non-homogeneity of silage. The modified method involved three extractions of the alkali-digested silage in a Waring blendor, with Skellysolve B, alcohol and Skellysolve B, respectively. The extracts were combined and the alcohol was washed out with water. The Skellysolve B extract was concentrated to 30–40 ml., and the carotene was separated from other pigments by use of a magnesia adsorption column (3).

Mitchell and King (1) recently have proposed a method for determining carotene in alfalfa and cereal grasses which appreciably reduces sampling error. The method consists of drying the blanched or autoclaved plant tissue for 4 hours at 65° C., grinding the dried tissue and extracting the carotene from the resulting meal by the procedure of Silker *et al.* (3) for dehydrated alfalfa meal. Since a representative sample is obtained much more easily from the dried meal than from the chopped plant tissue, this method yielded reproducible results.

The method of Mitchell and King (1) has been compared with the modified procedure of Peterson *et al.* (2) to determine if it could be used for analysis of silage. Samples of sorghum silage were thoroughly mixed and quartered. One quarter was autoclaved for 10 minutes at 10 lb. pressure and dried in a circulating air oven for 4 hours at 65° C. Another quarter was dried without prior autoclaving. Three 20-g. samples were taken from a third quarter for carotene determination by the modified method of Peterson *et al.* (2). Samples were taken also for moisture determinations. The dried samples were ground to pass through a 20-mesh screen. Carotene was extracted from 5-g. samples of the meal by soaking overnight with 120 ml. of 30 per cent acetone in Skellysolve B. The remainder of the determination was conducted as specified by Silker *et al.* (3).

Comparisons of the results obtained by the two methods are presented in table 1. Replicates generally were in closer agreement by the Mitchell and King (1) procedure than by the modified Peterson *et al.* (2) method. In some instances, the variation by the latter method was such that an average of the three values for a given silage had little meaning. Grinding the undried silage with a food chopper or cutting it finely with scissors perhaps would have reduced sampling error, but this leads to uncertainty due to loss of tissue fluids.

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As a further check on the method, carotene was determined by the modified method of Peterson *et al.* (2) on 5-g. samples of the meal obtained from the autoclaved portion of silage no. 6. The values obtained were 21.8, 23.5 and 24.3 μg. (average 23.2 μg.) per g. dry weight. This compares satisfactorily with 21.7 μg. obtained by the same method on the original silage and 23.6 μg. obtained by the Mitchell and King (1) procedure on the meal (table 1). These values indicate that there could have been but little carotene destruction in the silage during drying.

The data of table 1 also show that autoclaving sorghum silage before drying for analysis did not result in appreciably higher carotene values than if the

TABLE 1

Comparison of the Mitchell and King procedure and the modified Peterson et al. method for the determination of carotene in sorghum silage

Sample	Modified Peterson, Hughes, Freeman		Mitchell and King			
			Unautoclaved		Autoclaved	
	(μg./g.[a])	(av.)	(μg./g.[a])	(av.)	(μg./g.[a])	(av.)
1	45.3 46.7	46.0	53.7 55.8	54.7	53.4 54.4	53.9
2	30.2 33.6	31.9	.....	.....	32.5 32.5	32.5
3	43.5 54.3 55.5	51.1	43.1 45.9	44.5	45.9 47.6	46.8
4	54.3 58.8 60.7	57.9	42.7 42.7	42.7	46.7 48.5	47.6
5	58.2 77.7 94.1	76.7	44.7 45.4	45.0	47.7 48.6	48.2
6	19.9 22.2 23.0	21.7	19.9 20.1	20.0	23.3 24.0	23.6
7	15.6 17.5 19.4	17.5	14.3 14.7	14.5	14.0 14.8	14.4

[a] Dry weight basis.

silage was dried without prior autoclaving. Sorghum silage differs in this respect from fresh alfalfa, for the latter must be blanched or autoclaved to prevent enzymic destruction of carotene during drying. Lack of carotene destruction during the drying of silage may be due either to absence of the enzyme in the original plant material, or to enzyme inactivation by the ensiling process. If the method is to be used with other types of silage, the material should be autoclaved before drying, unless it first is shown that such treatment does not result in higher carotene values.

Since it usually is necessary to make proximate analyses as well as carotene determinations on the silage, a further advantage of the procedure is that both can be made on the same dried sample. Such dried samples, if held at low

temperatures, need not be analyzed for carotene immediately. Hence, the method is adaptable to routine laboratory procedures.

SUMMARY

The Mitchell and King (1) procedure for determining carotene in fresh plant tissue is suitable for the determination of carotene in silage. Sampling error with this method is much less than with a modification of the Peterson *et al.* (2) method. Autoclaving sorghum silage before drying did not appear be be necessary in the analysis by this method.

REFERENCES

(1) MITCHELL, H. L., AND KING, H. H. Determination of Carotene in Alfalfa and Cereal Grasses. Anal. Chem., 20: 637–638. 1948.

(2) PETERSON, W. J., HUGHES, J. S., AND FREEMAN, H. F. Determination of Carotene in Forage. Ind. Eng. Chem., Anal. Ed., 9: 71–72. 1937.

(3) SILKER, R. E., SCHRENK, W. G., AND KING, H. H. Determination of Carotene in Dehydrated Alfalfa Meal. A Simplified Method. Ind. Eng. Chem., Anal. Ed., 16: 513–515. 1944.

INFECTIOUS DISEASE AS A CAUSE OF INFERTILITY: A REVIEW[1]

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INTRODUCTION

Diseases impairing reproduction strike at the fundamental operation of cattle husbandry. Heifers late in producing or never producing calves and cows producing calves at longer intervals than normal or never again producing calves, obviously fail to yield their entire potential profit. Fewer calves and lactations, prolonged lactations and dry periods, with maintenance costs constant or only moderately decreased, all contribute to the accumulated loss. Infectious diseases are productive of financial loss to the owner of affected cattle by interfering with coitus, by preventing conception temporarily or permanently, by interrupting pregnancy during any stage from fertilization to parturition, or by causing stillborn, moribund or feeble calves.

The ability to reproduce may be temporarily impaired during the course of any systemic condition associated with general debility or increase in body temperature; in bulls, spermatogenesis may be affected and quantity and quality of semen markedly altered, non-pregnant females may become anestrous, and pregnant females may abort. Diseases that are primarily systemic, however, are not within the scope of this paper. Discussion herein will be confined to those infectious diseases detrimental to reproduction that involve invasion by pathogenic organisms of some portion of the genitalia of either or both sexes. These diseases, in so far as their relationship to the genital system and its reproductive functions are concerned, are either (a) unspecialized or (b) specialized. The former are sporadic infections, either non-contagious or only slightly contagious, caused by organisms capable of causing disease of any part of animal bodies. The latter are contagious infections caused by organisms characterized by their specificity for particular species of animals and their decided predilection for, and more or less definite pattern of involvement of, the genital system.

Obviously, most genital infections do not result in absolute sterility. Some infections are of short duration and may leave no permanent effects. Other transient infections may leave lesions which impair or preclude reproduction. In bulls, malfunction of the testicles or accessory sex glands or occlusion of the tubular system may result. In females, extensive adhesions around the ovaries, occlusions of the oviducts, destruction of the functional lining of the uterus, and enlargement and distortion of the cervix all may occur. Some local infections may persist in the chronic stage and result directly in life-long, capricious fer-

[1] Based upon a paper presented in the symposium on Reproductive Problems of Dairy Cattle at the 43rd Annual Meeting.

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tility. Still other infections, after a phase of activity characterized by inability to produce viable young for several years, become latent as a result of resistance acquired by the affected individual; thereafter, the ability to reproduce in an essentially normal fashion may be regained despite the existing infection. Some infections do not interfere with conception but prevent nidation, cause embryonal death, or interrupt pregnancies when well established. In such latter instances, the structures critically affected are those of the conceptus—the foetal placenta and the developing calf. Other infections, as a result of associated pain, may be responsible for diminished libido and consequent refusal of opportunity for coitus by bulls or resistance to coitus by females in estrum.

UNSPECIALIZED INFECTIONS OF THE REPRODUCTIVE SYSTEM

The unspecialized infections capable of causing reproductive failures usually require some predisposing condition in order to become established. They usually are local infections and frequently are of a type associated with production of pus. The organisms responsible occasionally may be transferred at coitus, but these are neither venereal diseases nor diseases that occur epizootically.

In females, lacerations such as those that sometimes occur at parturition or the conditions incident to decomposition of retained placentas may afford the opportunity for establishment of non-specific infections. In bulls, infections sometimes may ascend the urogenital tract. Also, in either sex, organisms may be brought to an area by the bloodstream and become localized. Vulvo-vaginitis cervicitis, metritis, salpingitis and ovarian bursitis in females and balanoposthitis, urethritis, seminal vesiculitis, inflammation of the other contributing genital glands, deferentitis and epididymo-orchitis in bulls may occur singly or in combination and in varying severity in the respective sexes. Streptococci, staphylococci, corynebacteria and *Pseudomonas pyocyaneous* are among the organisms which have been incriminated. Infection of the conceptus with termination of pregnancy, rarely in pyometra or more commonly in frank abortion, particularly in the later stages of gestation, may occur. Many unspecialized organisms, including streptococci, staphylococci, corynebacteria, diplococci, micrococci, molds and intestinal organisms, have been cultured from aborted fetuses (28).

The organisms concerned in these unspecialized diseases are ubiquitous in the environment of cattle and cannot be eradicated from a herd. Fortunately, these diseases are not among the most serious problems. They will continue to occur occasionally in herds despite the best management practices. Their treatment is largely symptomatic. That these diseases are diagnosed properly is very important in order that rational remedial measures may be employed and that applications of wrong therapeutic measures do not add further to the loss. Also, it is important that these diseases do not confuse the picture when infections that are specialized for the genital system are being dealt with.

SPECIALIZED INFECTIONS OF THE REPRODUCTIVE SYSTEM

Vesicular venereal disease (*coital exanthema, genital pox*) (*14, 23*). This is a highly transmissible, primarily venereal disease of cattle that occurs very rarely

in the United States, although it is reported rather commonly in Europe. Its etiological agent is believed to be a virus. This infection is characterized by its short incubation period of only 3 to 6 days and its lesions affecting the genital membranes. These begin as small papules and develop into lymph-containing vesicles that rupture and form ulcers which heal in about 2 weeks if uncomplicated. Affected individuals evidence considerable local pain; females may bawl and urinate frequently with much switching of their tails; bulls refuse coitus. Owing to its short course and prompt resolution, the effects upon fertility are not outstanding. However, individuals, particularly bulls, may be left with extensive adhesions requiring surgical intervention to restore coital function. The effects of this infection upon the uterus, germ cells and conceptus are unknown.

Treatment ordinarily is unnecessary, recovery being rapid and spontaneous. Individuals in which the inflammation is particularly acute may be benefited by irrigation with mild antiseptic solutions.

Although this disease is uncommon in its occurrence and not a cause of prolonged reproductive failure, it is important and merits restudy because of its potentialities. Vesicular venereal disease may become common in the United States at any time. Since it has been suggested that the virus of this disease is resistant outside the body, its relationship to artificial insemination should be thoroughly explored experimentally. Although this disease does not seem to have serious consequences, inadvertent transmission by artificial insemination would cause justifiable concern among cattle owners.

Bovine venereal trichomoniasis. Losses directly attributable to bovine venereal trichomoniasis, currently being experienced by cattle raisers of the United States, cannot be determined precisely, because the distribution and incidence of infected herds are unknown. Although this disease has been recognized in almost every State, only in Wisconsin have efforts been made to determine its occurrence and relative importance. Morgan, of the University of Wisconsin (19), reports that in the 6 years, from 1941 to 1946, 61 infected herds were found by the University's diagnostic service.

In the area within approximately 100 miles of the Agricultural Research Center, Beltsville, Maryland, the records of nine trichomonad-infected herds, having a total of more than 800 cattle, have been studied by members of the Zoological Division since 1934. Of these herds, four were purebred Aberdeen Angus; two were Guernsey, one purebred and one grade; and three were Holstein-Friesian, one purebred and two grade. These herds are in no way a significant indication of the occurrence of bovine venereal trichomoniasis in the Beltsville area, as no special effort has been made to locate infected herds. Their owners solicited the professional aid of either the University of Maryland Livestock Sanitary Service or the U. S. Bureau of Animal Industry. Nevertheless, the financial reverses experienced in these nine herds are believed to be highly significant. Two hundred thousand dollars is a conservative estimate of the loss of potential production of milk and calves and the loss of value of infected sires up to the time bovine venereal trichomoniasis was recognized as responsible for the reproductive failures in these infected herds (5).

This disease is caused by a protozoon, *Trichomonas foetus,* and is transmitted naturally only at coitus. However, mechanical transfer does occur readily between females through careless use of instruments or to females through artificial insemination with semen from infected bulls.

The direct deleterious effects of trichomoniasis are manifested almost entirely in the female, the uterus being the definitive site of infection. Infected females develop active immunity and ordinarily recover spontaneously. In bulls, *T. foetus* ordinarily lives on the surface of the preputial membranes and glans penis, produces no significant symptoms and ordinarily influences neither functional fertility nor potency. Bulls remain infected permanently, transferring trichomonads at practically every coitus.

In affected females, the most consistent effect is early termination of pregnancy, the relative time at which the developing conceptus is destroyed determining the symptoms displayed in individual cases. Most females, particularly those experiencing initial infections, return to estrum within 3 to 5 weeks *post coitum.* Trichomonad infection continues for several months during which time the females are infertile. Some females may abort recognizable fetuses during their first few months of pregnancy, in others the fetus may be liquified and pus may be accumulated in the uterus. This latter condition may persist for a year, superficially simulating pregnancy. On recovery from infection, most females are resistant to reinfection for a few years and may reproduce normally from coitus with infected bulls; eventually, however, the immunity is lost and reinfection occurs if coitus with trichomonad-infected bulls is permitted.

Diagnosis is based on actual demonstration of *T. foetus* in material collected from the genitalia of females or bulls.

The complete eradication of this disease from affected herds is the only effective means of handling this condition; ultimately, it is the most economical. Eradication involves the following steps: (a) Recognizing trichomonad-infected bulls and promptly withdrawing them from service (subsequent to successful treatment the previously infected valuable bulls may be restored to service) and (b) maintaining a constructive breeding program for all females in the herd, regardless of their status, systematically breeding each potentially infected female when she becomes free of infection and preventing her re-exposure incident to subsequent coitus.

Treatment of trichomonad-infected bulls is still on an experimental basis, but two methods subjected to limited but carefully controlled experimental trials conducted at the Zoological Division at Beltsville have shown considerable promise. These are (a) intravenous administration of large doses of sodium iodide (10 of 19 infections in 17 bulls were cured through experimental administration of 31 courses of iodides), and (b) topical application of a German-developed proprietary compound[3] (ten infected bulls were treated and nine were cured by a single treatment; one remained infected despite two treatments). Details of progress to date with experimental treatments for trichomonad-infected bulls have been reported elsewhere (2, 3).

[3] "Bovoflavin-Salbe"—Farbwerke Hoechst, Frankfort (m)-Hoechst.

Although results are encouraging, it is apparent that research has not yet progressed to a point where treatment of trichomonad-infected bulls can be recommended for general field use. Also, treatment of bulls is an exacting, lengthy, costly procedure requiring frequent handling and observation of the subject over a period of 6 months by a veterinarian familiar with trichomoniasis. Under practical field conditions, infected bulls not of exceptional value (at least three times their salvage value) as sires should be promptly slaughtered.

A procedure that has been found effective, experimentally, in systematically ridding seven of eight infected herds of bovine venereal trichomoniasis and the premise on which it is based have been fully described elsewhere by Bartlett and Dikmans (6). Application of this program necessitates extraordinary cooperation and understanding between the management of the infected herd and the attending veterinarian, for it is a laborious, long-term, expensive undertaking that requires much patience, many examinations, much careful bookkeeping and constant, alert herd management.

Herd owners introducing animals for breeding may afford their herds considerable protection by observing a few principles and precautions, namely: (a) Knowledge that the reproduction efficiency in the herd of origin is satisfactory is an excellent safeguard against selecting trichomonad-infected cattle. (b) Thorough examination of new suspect bulls by the diagnostic methods now available and examination of the first several females with which they are permitted coitus is indicated (4, 7, 8). (c) By prohibiting coitus of new, non-virgin, non-pregnant heifers and of new, non-pregnant cows that have had coitus since their latest parturition, introduction of trichomoniasis by females is precluded. The breeding of such females should be accomplished by artificial insemination only. New cows that have not had coitus since their latest normal parturition should be withheld from coitus until they have passed at least 2 estrums and rested at least 90 days postpartum.

Trichomoniasis may be disseminated readily to susceptible breeding females by artificial insemination, should semen from infected bulls be employed. The danger of unintentionally contributing to the spread of this disease merits constant serious consideration by responsible artificial insemination organizations. It is of extreme importance that the status of all bulls serving in such units be carefully determined by a competent diagnostician. It behooves herd owners to ascertain that the semen they are buying is from trichomonad-free bulls.

The outstanding need today for more effective control of bovine venereal trichomoniasis is a rapid, accurate, "one sample" means of determining the status of females and bulls, particularly the latter.

Bovine Vibrio fetus infection.—Vibrio fetus generally is recognized as a cause of occasional abortions in herds throughout the United States. Pregnancies may be terminated at almost any stage, but most frequently during the fourth to sixth month (second trimester) or seventh month. The manner of transmission is unknown. Precise knowledge of its incidence and epizootiology does not exist.

In the United States, abortion associated with vibrios was first described by Theobald Smith in 1918 (24). Later he reported that 26, or 23.8 per cent of a series of 109 aborts, originating from a large dairy herd in New Jersey, revealed *V. fetus* on bacteriological studies. Smith described the diseased state of the placentas of affected females. Subsequently, no significant contributions relative to cattle appeared until Plastridge (20, 21) of Connecticut became interested in this condition. Recently, he reported studying 10 *V. fetus* infected herds in which the annual abortion rates attributed to *V. fetus* were 4 to 20 per cent and averaged 12 per cent. Also, Plastridge observed a lowered conception rate in five of these herds. He has devised an experimental agglutination test for diagnosis.

Since the manner of transmission is unknown and the usual method of diagnosis difficult, rational means of coping with this disease in those herds in which it constitutes a problem are not available. Of course, general procedures in animal hygiene are indicated. All females in which abortion can be anticipated—and, ideally, all females at normal parturition—should be isolated and quarantined at least until genital discharges terminate.

It is evident that bovine *V. fetus* infection ordinarily is not responsible for the "storms" of abortion sometimes associated with bovine brucellosis. However, in the light of the present decline of bovine brucellosis, *V. fetus* as a cause of impaired reproduction today merits thorough experimental exploration.

Bovine brucellosis. Among the infectious diseases causing infertility, bovine brucellosis is still responsible for the greatest financial losses. Mingle (18), has estimated conservatively that in 1947 the beef and dairy cattle industries of the United States absorbed total losses of $91,000,000 attributable to this disease. Bovine brucellosis and the problems incident to its control and eradication are well known; discussion in this brief paper would not be justified. Rational means of combating this disease are at hand. Their diligent application is indicated.

CONDITIONS OF QUESTIONABLE SPECIFICITY AND SPECIALIZATION

Nodular venereal disease (granular vaginitis, nodular vaginitis). To present an unprejudiced discussion of nodular venereal disease is exceedingly difficult. Pertinent to this subject one finds a paucity of established facts scattered among widely controversial opinions. This condition first received notice toward the close of the 19th century and was the subject of research by several workers. Since that time, much has been written regarding its importance and treatment, but no reports of comprehensive creditable research on its etiology and precise effects have been published. As far back as 1921, Williams (27) deplored the fact that this condition had not received serious study by pathologists and bacteriologists and pointed out that, "It may be said to be a lesion without a known cause and regarding the effect of which there is scant knowledge." That controversy still exists is evinced by recent literature where state-

ments were found that this disease is an outstanding cause of infertility (10, 13, 16), that although very common, only occasionally does this disease develop to the extent that it causes serious breeding troubles (9), and to the effect that this condition is of importance only to nostrum vendors in marketing their wares (23).

Some animals exhibiting the lesions ascribed to this condition can be found in most herds of cattle. In many females the lesions are confined to the vulva and may occur only about the clitoris, there being no involvement of the vagina. In other females the vulva and vagina may exhibit moderate to severe inflammation with rather general distribution of nodules. Lesions may be found in immature virgin heifers. It is not unusual to find severe lesions in females in all stages of pregnancy, whether their prior breeding records were normal or abnormal. On the preputial membrane and glans penis of bulls, nodules similar to those of females and inflammation may be found. Bacteriological studies have not revealed a specific organism consistently present in affected individuals. Neither has it been clearly demonstrated experimentally that this condition can be regularly reproduced artificially with consequent infertility nor has the contrary been demonstrated. It is possible that this condition is not primarily infectious.

Markedly affected individuals may be benefited by occasional douches with mild antiseptic solutions or, perhaps better, by occasional insufflation with absorbent antiseptic powders. Too vigorous or frequently repeated treatments are harmful. Application of treatments to an entire herd ordinarily is not justified.

There are admittedly many blanks in our present understanding of this condition. Nodular venereal disease should be the subject of a serious comprehensive research program designed to determine its cause, effect upon the reproductive capacities of the bovine and remedy.

MISCELLANEOUS INFECTIONS OF UNDETERMINED SPECIALIZATION AND UNKNOWN IMPORTANCE

Several species of molds have been reported recovered from aborted fetuses by a number of workers (15). Recently, from England, Rollinson and Haq (22) reported they found the same mold harbored in the prepuce of a bull that they found *post abortum* in the cervical mucus of a cow whose pregnancy had been initiated earlier by their coitus.

From England, pleuropneumonia-like organisms recently have been reported by Edward *et al.* (11) to have been isolated from the genital tracts of cows and bulls in herds without other ascribable cause for infertility. Affected females sometimes had cervicitis and adhesions of ovarian bursae.

From Holland a disease termed "enzootic sterility" has been described by Sjollema (23) and Ter Borg (25) and probably is the same as that described earlier by Webster (26) from New Zealand. This condition is described as a venereally-transmitted streptococcic affection of the uterus, cervix and vagina associated with return to estrum and early abortions.

In England several writers (1, 12, 17) have described a condition of breeding females known as "whites" associated with sterility and characterized by genital discharge post coitum and postpartum. Some claim this condition is caused by *Corynebacterium pyogenes* and is spread by coitus.

These latter fragmentary reports warrant further investigation. If the observations of the writers are confirmed, thorough experimental exploration is indicated.

GENERAL DISCUSSION AND RECOMMENDATIONS

For some infectious diseases, relatively effective prophylactic and combative procedures have been developed; dairymen and veterinarians need only to take cognizance of the established precepts. However, our present inability to cope rationally with certain other conditions and the meagerness of the knowledge of their total effects and causes must be recognized. Well directed, well supported scientific research is the only source from which the necessary facts can be obtained. Such research merits the encouragement, interest and support of the cattle industry and veterinary profession alike. It is obvious that the causes of lowered reproductive efficiency are exceedingly numerous and the problems of achieving optimum reproductive efficiency exceedingly complex and broad in their ramifications. No panaceas must be expected. Precise diagnoses whenever possible, rational corrective actions when indicated and trained, intellectually honest advisors mark the sound course. There should be no place for the triflers, "five-day specialists," self-confident, self-styled, handyman experts and quack remedy peddlers parasitizing and exploiting the field today.

For the cattleman, consistent observance of sound management and animal hygiene practices is imperative. Before introduction of breeding animals from outside herds, it is well to investigate their individual breeding records and also the general reproductive performance of their herds of origin. The keeping of precise, permanent records, together with a system of regular, physical examinations for pregnancy, will reveal any general occurrence of reproductive failures at the onset and by permitting early treatment or disposal of affected animals, will keep to a minimum the economic reverses resulting from infertility. Accurate, individual records are extremely valuable to the veterinarian in diagnosis and in planning treatment. Isolation of females when impending abortions are apparent and isolation of females after abortion and at calving time, at least until discharges cease, are indicated practices.

REFERENCES

(1) ANONYMOUS. The control of Certain Diseases of Dairy Cattle, Vet. Record, 54: 194–196. 1942.

(2) BARTLETT, D. E. Experimental Treatment of *Trichomonas foetus* Infection in Bulls, Am. J. Vet. Research, 7: 417–431. 1946.

(3) BARTLETT, D. E. Further Observations on Experimental Treatment of *Trichomonas foetus* Infections in Bulls. Am. J. Vet. Research, 9: 351–359. 1948.

(4) BARTLETT, D. E. Summary of Procedures for Diagnosing Bovine Venereal Trichomoniasis and Handling Affected Herds. J. Am. Vet. Med. Assoc. (in press).

(5) BARTLETT, D. E. Unpublished data in files of Zoological Division.
(6) BARTLETT, D. E., AND DIKMANS, G. Field Studies on Bovine Venereal Trichomoniasis: Effect on Herds and Efficacy of Certain Practices in Control. Am. J. Vet. Research. (in press).
(7) BARTLETT, D. E., AND HAMMOND, D. M. Pattern of Fluctuations in Numbers of *Trichomonas Foetus* Occurring in the Bovine Vagina During Initial Infections. II. Application in Diagnosis. Am. J. Vet. Research, **6**: 91–95. 1945.
(8) BARTLETT, D. E., HASSON, E. V., AND TEETER, K. G. Occurrence of *Trichomonas foetus* in Preputial Samples from Infected Bulls: Application in Diagnosis. J. Am. Vet. Med. Assoc., **110**: 114–120. 1947.
(9) BOYD, W. L. Disease, Biggest Cause of Shy Breeding. Successful Farming, **45**: 24. 1947.
(10) CUNKELMAN, J. W. The Clinical Diagnosis and Treatment of Breeding Unsoundness in Cows. J. Am. Vet. Med. Assoc., **112**: 295–297. 1948.
(11) EDWARD, D. G., HANCOCK, J. L., AND HIGNETT, S. L. Pleuropneumonia-like Organisms from the Bovine Genital Tract. Vet. Record, **59**: 329–330. 1947.
(12) HIGNETT, S. L. Bovine Sterility. Vet. Record, **52**: 361–368. 1940.
(13) HORNADAY, W. A. Sterility in Cattle. Vet. Med., **42**: 129–133. 1947.
(14) HUTYRA, F., MAREK, J., AND MANNINGER, R. Special Pathology and Therapeutics of the Diseases of Domestic Animals. Vol. 1. Alexander Eger, Chicago. 1938.
(15) JUNGHERR, E. Mycotic Affections of the Bovine Reproductive System. J. Am. Vet. Med. Assoc., **86**: 64–75. 1935.
(16) KRILL, W. R. Granular Vaginitis and Steriiity. North Am. Vet., **29**: 308–309. 1948.
(17) MCEWEN, A. D. Notes Concerning Abortion, Mastitis and Sterility. Vet. Record, **54**: 155–157. 1942.
(18) MINGLE, C. K. Bureau of Animal Industry. Personal communication. 1948.
(19) MORGAN, B. B. Personal communication.
(20) PLASTRIDGE, W. M., AND WILLIAMS, L. F. Observations on *Vibrio fetus* in Cattle. J. Am. Vet. Med. Assoc., **102**: 89–95. 1943.
(21) PLASTRIDGE, W. M., WILLIAMS, L. F., AND PETRIE, DOROTHY. Vibrionic Abortion in Cattle. Am. J. Vet. Research, **8**: 178–183. 1947.
(22) ROLLINSON, D. H. L., AND HAQ, I. Mycotic Infection of the Prepuce of the Bull. Vet. Record, **60**: 69–70. 1948.
(23) SJOLLEMA, P. Onvruchtbaarheid Enzootische Steriliteit Bij Het Rund. Tijdschr. Diergeneesk, **68**: 508–515. 1941.
(24) SMITH, T. Spirilla Associated with Disease of the Fetal Membranes in Cattle (Infectious Abortion). J. Exptl. Med., **28**: 701–719. 1918.
(25) TER BORG, H. Enzoötische Steriliteit Bij Het Rund. Tijdschr. Diergeneesk., **70**: 40–54. 1943.
(26) WEBSTER, W. M. Bovine Sterility in New Zealand. Australian Vet. J., **8**: 199–222. 1932.
(27) WILLIAMS, W. L. Diseases of the Genital Organs of Domestic Animals, 1st edn. The Author, Ithaca, N. Y. 1921.
(28) WILLIAMS, W. L. Diseases of the Genital Organs of Domestic Animals. 2nd edn. The Author, Ithaca, N. Y. 1939.

HORMONES AND THE TREATMENT OF STERILITY IN DAIRY CATTLE: A REVIEW*

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During the past few years considerable attention has been paid to the use of hormones as means of correcting infertility in live stock. In many animals in which disease is not very evident, derangements of the normal estrous cycle occur which should be amenable to this type of treatment. These include cases in which the cycle does not occur at all, possibly because the anterior pituitary gland is not functioning correctly or because the corpus luteum persists, preventing the regular cycle of events. Another type of hormonal disorder is found in the nymphomaniac in which the Graafian follicle fails to rupture and becomes cystic, thus causing the cycle to be interrupted. It also has been suggested that many cows with fairly regular cycles fail to conceive or to carry their calves to term because the corpus luteum or the uterus is not performing its function efficiently. Further, it has been suggested that resistance to diseases of the genital tract may be increased in some instances by reinforcing the normal hormonal mechanism. In this review, a list of the hormones available, their major functions and their best sources is given. This is followed by a statement of the point of view adopted by the writer and by an analysis of reports of the attempted use of these hormones in experimental work and in the field. This last part of the review deals with these problems as they are seen to occur in the field, *i.e.* the clinical condition is the basis of classification of the literature. As this part of the review is developed, certain gaps in our knowledge are pointed out as suggestions of the lines along which further data should be sought if progress is to be made. At the outset, it may be stated that the greatest need at present is for good assay methods so that hormone levels may be determined on individual cows. This is an important requisite if rational hormonic treatment is to become possible. Too much of the work, so far, has been along empirical lines, due not to shortcomings in the investigators but to their lack of effective tools.

HORMONES AVAILABLE

I. Anterior pituitary gonadotrophes

a. Follicle stimulating hormone, causes growth of the Graafian follicle (after an antrum has been established) and spermatogenesis. Best source, horse pituitary; very little in cattle pituitaries, and not much in sheep or hog pituitaries.

b. Luteinizing hormone, causes ovulation of a ripe Graafian follicle and formation of the corpus luteum, and also causes the cells of Leydig to secrete testosterone in the male. Best source, sheep and hog pituitaries.

* Based upon a paper presented in the symposium on Reproductive Problems of Dairy Cattle at the 43rd Annual Meeting.

c. Prolactin, causes the corpus luteum to secrete progesterone. No known function in the male.

These hormones are proteins and are not likely to be synthesized for a long time, so the only source is from pituitary glands. Extracts of the glands contain a mixture of these hormones. Prolactin is separated from the others fairly readily and can be purified with relative ease. The other two are not separated readily and pure preparations, though they have been made, are not available. The writer's experience has been that pure luteinizing hormone can be prepared but not in sufficient quantity for use. Follicle-stimulating hormone is so soluble that it is not readily obtained pure. McShan and Meyer (34) destroy the luteinizing hormone of extracts by tryptic digestion which leaves the follicle stimulator more or less unattacked.

II. Other gonadotrophins

a. Chorionic gonadotrophin from the urine of pregnant women. Entirely luteinizing in its action.

b. Human ovariectomy or menopause urine. Entirely follicle stimulating in its action.

c. Equine gonadotrophin from the blood serum of mares between 45 and 150 days of pregnancy. Entirely follicle stimulating in its action.

One of the main difficulties in the use of gonadotrophic hormones in animals with their pituitaries intact (a method of procedure which is obligatory in therapy) is that all these hormones are acting in the presence of the animal's own pituitary hormones which tend to modify the activity of the injected material. Also, by their action on the ovary or testis, the balance is altered for better or worse.

III. Sex steroids.

a. Estrogens. These hormones, secreted by the theca interna cells of the Graafian follicle and by the placenta, cause the psychic symptoms of heat, increase the blood supply to the endometrium, activate the myometrium and reduce the alkalinity of the vaginal secretion, thus promoting the liquifaction of the uterine seal. Estradiol is the most potent, then estrone and estriol. They are slightly soluble in water and much more so in oil, and usually are injected in the latter medium. This causes slow absorption and, in practice, as they are given as esters (e.g., estradiol monobenzoate) absorption is very slow, indeed. These hormones also cause the pituitary to change from follicle stimulating to luteinizing hormone secretion.

b. Progesterone, secreted by the corpus luteum, causes glandular growth of the endometrium and, in general, inhibits the activity of estrogens. It also is essential for the implantation of the embryo and probably is essential in the cow for the maintenance of pregnancy for the greater part of the period of gestation.

c. Androgens. These are secreted by the cells of Leydig of the testis. They are responsible for sexual desire and for the maintenance of the accessory

sex organs in the male. Testosterone is the most powerful, followed by androsterone.

All these natural steriods are obtained from animal sources, estrogens from pregnancy urine, androgens from the urine of males and progesterone from corpora lutea. They also are synthesized, especially in the case of progesterone, beginning with certain sterols of vegetable origin. The use of natural estrogens rapidly is being replaced by the synthetic estrogens of group IV, below.

IV. Synthetic estrogens.

These do not occur in nature and are relatively simple in structure. They also have the advantage that they may be fed, not being destroyed in the gut as are the natural estrogens to a large extent. They have the biological properties of the natural estrogens.

a. Diethylstilbestrol (stilbestrol).

b. Hexestrol.

c. Octofollin.

d. Dienestrol, now being tried extensively, as it is more water soluble than the preceding and consequently is absorbed more easily, with a correspondingly more rapid and shorter action.

Our experience with diethyl stilbestrol has been that it is so slowly absorbed and excreted that it has a prolonged action, which may be detrimental to the return of normal sexual function. All the estrogens, both natural and synthetic, if given over a sufficiently long period cause nymphomania, with the usual symptoms, sinking round the tail head and liability to bone fracture, found in chronic cases. If given in pregnancy in sufficiently large doses, they cause abortion.

V. Other hormones

a. Oxytocin. This hormone, secreted by the posterior pituitary gland, causes the myometrium to contract. It is used either as such, or in the crude preparation, pituitrin, to hasten birth or to expel the retained placenta. Estrogens, by their action in stimulating the spontaneous activity of the myometrium, have much the same effect.

b. Thyroxin. This hormone, secreted by the thyroid gland, controls the basal metabolism and thus is essential for the efficient function of every cell of the body. There is evidence from gynecology that hypothyroidism often is associated with infertility, so this hormone must be considered in any account of hormone therapy. A synthetic form, thyroprotein, is available. It has the advantage over most hormones that it is not destroyed by the digestive juices, so it may be fed to the animal to be treated.

THERAPEUTIC USE OF HORMONES

The philosophy of the writer regarding the therapeutic use of hormones in the treatment of infertility stems largely from observations in an experiment made to test the usefulness of estrogens for this purpose (Asdell *et al.*, 7). In

this work, cows free from brucellosis, with no obvious signs of disease or abnormality and with fairly regular heat periods were treated with estrogens. The reason for selecting this method of treatment was that, since heat periods were fairly regular, the pituitary and ovaries probably were functioning normally but that the uterus was at fault. Estrogens were indicated since they increase the blood supply to the endometrium, thus giving a chance for better nutrition of that organ, and since they also stimulate the myometrium, thus improving the chance of normal function if that part of the uterus were at fault. The cows were bred naturally whenever they were in heat. Forty-two per cent of the treated cows conceived, but a control group had been included in the design of the experiment, and, of these, 50 per cent conceived in a fairly reasonable time. It is obvious that both in field trials and in experimental work this factor of spontaneous recovery must be taken into account. Adequate controlling is essential and it very rarely is found. The extent to which spontaneous recovery may affect the deductions varies with the criterion of sterility. Diagnosis of sterility by one veterinarian was followed by 12.5 per cent of spontaneous recovery; in our experiment, which may be regarded as fairly typical of the usual diagnosis in the type of infertility treated, the spontaneous recovery rate was 50 per cent; spontaneous recovery following diagnosis by another veterinarian was 85 per cent. This variation emphasizes the need for adequate controls in each trial which is made.

Further reflection pointed to the lack of logic in injecting hormones in empirical amounts when no information was available concerning the normal requirements of the cow and little on what various doses do to the cow's reproductive tract. Since that time, this situation has been corrected to a certain extent and the present knowledge on this subject has been brought together by Asdell (6).

Autopsy of the cows which did not conceive showed that, in most cases, disease of an erosive type had been present in the uterus, had damaged the cotyledons and then had cleared up. This also was borne out by the rather high abortion rate in the cows which conceived. Experience in this and in other instances leads the writer to believe that hormonic dysfunction is usually the result of disease factors which have upset the normal balance. In many cases, the structural damage which has been done is such that repair cannot be made. Primary hormonic inbalance in dairy cattle is by no means common. Functional sterility usually is the result of disease or of malnutrition.

In some types of infertility, the number of services needed for conception after treatment may be used with caution as a criterion of success, but even here a controlled experiment is preferable.

There has been too much tendency to apply hormones to all types of infertility on a shotgun basis without attempting to fit the treatment to the symptoms. As a result of this and due to the lack of controls, most of the work that has been done, both in the laboratory and in the field, must be taken with considerable reserve. In the account which follows, an attempt has been made to assess the reliability of the information given bearing this in mind. The method

of presentation is to consider different types of infertility separately. In practice, a combined therapy aimed at elimination of the casual agent and at rectification of the hormonal inbalance is indicated, but where this method has been used, assessment of the value of the hormonal therapy becomes problematical.

Generally speaking, the earlier literature is far more optimistic than the more recent. The earlier workers, particularly those on the European continent, often report "cures," apparently meaning that the symptoms have disappeared without indicating that the all-important conception has followed. Furthermore, in many reports, including recent ones, a few case histories are given describing successful treatments but with no reference to unsuccessful attempts.

THE FREEMARTIN

Attempts by the writer to modify the freemartin by the injection of estrogens have failed. In the four cases examined, the Mullerian ducts had lost the power of response to estrogens. As the gonad usually is a rudimentary cryptorchid testis, treatment with gonadotrophes is not indicated. Small gonads with ovarian stroma, but devoid of germinal epithelium, sometimes are observed but probably would not respond to gonadotrophes sufficiently to become functional.

INFANTILE OVARIES

Infantile ovaries, with the consequent failure of the accessory organs to develop, are due to a variety of causes. They may be due to late development, genetic in nature, or to failure for other reasons not yet understood, but usually the condition follows malnutrition in early life. The condition seems to be more frequent in more northern latitudes and lack of sunlight may be a factor. This may not be the primary factor involved, since high latitudes suffer from prolonged winters with consequent lack of succulent feed and a prolonged dry feeding period. The condition usually is found in heifers towards the end of winter, and it often is diagnosed when a number of heifers have been running with the bull and a check discloses very few conceptions. This means that treatment usually is initiated in early spring, when feed and climatic conditions are improving. Successes are credited to the treatment without sufficient basis.

The logical treatment is to inject a gonadotrophic preparation, preferably one with follicle stimulating properties, such as equine gonadotrophin or horse pituitary. The reaction of the normal heifer calf before puberty has been investigated by Casida *et al.* (15) who used pituitary extracts, both fractionated and unfractionated. They found that a calf whose ovarian follicles had not developed antra failed to respond. A similar result has been obtained by Smith *et al.* (50) in the rat. Further investigation may show that this is a serious limitation to the activity of gonadotrophes. Casida *et al.* (15) also found that there is a real danger of producing superovulations and that the eggs shed have a poor capacity for fertilization. Zawadowsky and Eskin (59) have found that conceptions are rare in cows inseminated at the first heat following the injection of chorionic gonadotrophin (prolan). However, if the reproductive system

can be stimulated sufficiently, spontaneous ovulations subsequent to the induced one should be normal.

Most of the earlier workers used gonadotrophins, but the later ones have been relying upon the synthetic estrogen, diethylstilbestrol. The mode of action, if any, of this hormone is obscure. Several workers suggest that it acts by "jolting" the anterior pituitary, causing it to initiate a normal rhythm in the reproductive tract. Comment on this is reserved until the experimental results have been given.

Pighini (43) treated one heifer by grafting anterior pituitary tissue and injecting a crude anterior pituitary extract. She conceived. Asdell (5) treated 2 heifers with a crude anterior pituitary extract from sheep and both conceived, but not until they had been on grass for some time. Eisenbach (21) treated 15 heifers with 125 R.U. of chorionic gonadotrophin and 87 per cent conceived. Amilcare (3) treated 1 heifer with 325 R.U. of chorionic gonadotrophin without effect. Bottomley *et al.* (11) treated one heifer with chorionic gonadotrophins without result. Teunissen (55) treated 42 heifers with chorionic gonadotrophin; 26 came in heat and 18 conceived. He also treated 16 with equine gonadotrophin; 9 came in heat and 5 conceived. This gives 78 heifers treated with gonadotrophes with a pregnancy rate of 55 per cent.

Steinach *et al.* (53) treated 19 heifers with estradiol benzoate (Progynon B), 50,000 M.U. in one injection. Of these, 95 per cent came in heat within 2–4 days and 53 per cent conceived. Anderson and Bugg (4) injected 15 mg. of diethylstilbestrol diproprionate (the usual form in which this hormone is administered) into six heifers with small inactive ovaries. One came in heat, but none became pregnant. Allen (21) injected 18 heifers with the same substance and seven became pregnant. He notes that if heat was observed after the injections the chances of success were good and that the less the bodily development the poorer the outlook. Wright (56) injected 23 heifers with from 1,500 to 3,000 I.U. of stilbestrol; 5 came in heat and none conceived. It is not clear how long Wright persisted in his attempt to obtain pregnancy. Entirely negative results in experiments or trials of this nature are as difficult to explain as is 100 per cent success. If his report is omitted, 43 cows have been treated with estrogens with 40 per cent success.

On the basis of published results estrogen treatment of cows with infantile ovaries has been less successful than gonadotrophin treatment. Casida *et al.* (15), in their work with normal heifers, found the most successful treatment to be an initial injection of a follicle stimulator followed by an injection of luteinizer. This is a rational treatment, but it has not been followed in the field so far as published results show. Indeed, most workers have relied entirely upon luteinizer.

The idea that stilbestrol jolts the anterior pituitary into action is not supported by the results of this form of therapy. The effect of this substance upon the pituitary of the immature animal has not been worked out. More information is needed along these lines and also more is needed upon the condition of

the ovaries of those heifers which show no response, if there be one, to any form of therapy.

HYPOPLASTIC OVARIES IN THE ADULT

The condition of ovarian hypoplasia in the adult has points of similarity to that of infantile ovaries, but the condition found seems to be more variable. One cause is malnutrition. The ovaries may vary from a condition in which small follicles are present, without heat periods and ovulations, to a complete fibrous degeneration. The rational hormonic treatment is to inject a follicle stimulator, and, in some cases, this is reinforced by the classical massage treatment. Reports on treatment are numerous. Perhaps it might be as well to begin their consideration with a report by Clark (16) that of 15 treated by massage alone, 14 conceived.

Spieler (51) treated ten cows with a mixed estrogen and anterior pituitary preparation (hormovilan) and nine conceived. Asdell *et al.* (7) treated three cows with a sheep anterior pituitary extract and two conceived. Hupka and Majert (27) gave 60 cows one or two injections of 125–200 R.U. of prolan (chorionic gonadotrophin), a very small dose by more recent standards, and 62 per cent came in heat, while 47 per cent conceived. They also report the injection of 20 cows, with 90 per cent in heat after one to five injections. Bettini (10) treated nine cows of which eight were "cured." Amilcare (3) treated eight cows with 125 R.U. of prolan and all conceived. Eisenbach (21) treated six cows similarly and all were "cured." Menzani (35) treated 25 cows and 96 per cent came in heat. Pataki (42) treated 19 cows and 84 per cent came in heat. Koch (31) treated 34 cows which had anaphrodisia, a sequel to hoof and mouth disease. They received 250 R.U. of prolan, and conception at the first mating was recorded in 19 of them. Bottomley *et al.* (11) treated 19 cows and 6 conceived. Haisch (25) treated 12 and 11 conceived. Teunissen (55) treated 32 cows and 10 conceived. This gives a record of 165 cows treated with chorionic gonadotrophin with 50 per cent conceptions.

Kedrov (29) reports heat after treating cows with atrophic ovaries caused by underfeeding. His treatment consisted of injecting 1,000 M.U. of equine gonadotrophin, and he remarks that few of them conceived. Teunissen (55) treated two cows with the same type of preparation and both conceived.

Treatments with estrogens also have been numerous. Murphey *et al.* (38) treated two cows with an estrogen extract and both conceived. Steinach *et al.* (53) treated 66 cows by injecting 50,000 R.U. of estradiol benzoate (Progynon B) and 95 per cent came in heat. Bennewitz (9) gave 18 cows the same treatment; all came in heat and 54 per cent conceived. Ratti (46) reported heat in 44 of 55 cows similarly treated. Küpper (32) reported 36 treated with 20 in heat and 14 pregnant with another estrogen (Unden). Allen (2) treated four cows and obtained four pregnancies, while Mirskaja and Kedrov (36) treated one group of seven cows with 16 to 30 mg. of stilbestrol and reported six in heat and one pregnancy. They treated 16 cows which did not come in heat after parturition in a similar manner. Four of these ovulated but only one

conceived. Teunissen (55) treated four with another estrogen (Dimenformon) without success. Finally, Zollinger (6) treated 36 cows with stilbestrol and 58.8 per cent conceived. The total number of cows treated with estrogens is 123 and, of these, 53 per cent conceived.

Amongst miscellaneous types of hormone treatment of this type of infertility may be mentioned a report by Deubler and Barnes (19), who treated 19 cows by injecting an extract of one or two ovaries or by feeding extracts of two ovaries in a capsule. Eighteen of these cows came in heat, but, as natural estrogens are not absorbed from the gut in small doses, the successes cannot have been due to estrogens. Stäheli (52) treated 51 cows by transplanting one or two ovaries. Of these cows 85 per cent came in heat and 61 per cent conceived. Frei and Stäheli (23) treated nine cows with "vethormone" of which six came in heat and five conceived. This substance is a mixture of ovarian, pituitary, thyroid and pancreatic hormones.

SUBESTRUM

The English workers have described a condition which they term "subestrum." Animals which are classified thus do not come in heat, and small follicles are present in the ovaries but no corpora lutea. It appears to be a mild form of ovarian hypoplasia, and the type of treatment suggested should be the same as for that disorder.

Pataki (42) treated nine cows with 62 to 125 R.U. of chorionic gonadotrophin and seven conceived. Jensen (28) combined this treatment with uterine douches and ovarian massage. Of 47 cases treated, 46 came in heat and 79 per cent conceived. Zavadcvskii (58) treated 92 cows with equine gonadotrophin. Heat was recorded in 56 and pregnancy in 39. Wright (57) treated 18 cows with 15 to 25 mg. of stilbestrol. Seven came in heat regularly after the treatment but none conceived. Durrell (20) treated twelve with semen in the cervix and three conceived. A cow treated with equine gonadotrophin conceived, but with testosterone propionate only one of six became pregnant. One cow treated with progesterone conceived.

PERSISTENT CORPORA LUTEA

The usual treatment for persistent corpora lutea is to remove these bodies by squeezing them from the ovaries. In some cases, attempts have been made to treat with hormones. Spieler (51) used an anterior pituitary extract in 20 cases with 14 conceptions. Hupka and Majert (27) treated ten with small doses of chorionic gonadotrophin and seven came in heat. Menzani (35) used the same treatment in 20 cases, and 13 cows came in heat. Eisenbach (21) reported all cured with 21 treatments, while Teunissen (55) obtained three pregnancies in six treatments with the same substance. Cameron (12) treated 46 cows with equine gonadotrophin. Twenty-one came in heat, and he obtained some pregnancies.

Estrogens also have been used in this condition. Bennewitz (9) treated 15 cows with 50,000 R.U. of estradiol benzoate (progynon B); 94 per cent came

in heat, 75 per cent conceived, and 20 per cent became nymphomaniac. Küpper (32) treated 13 cows with a similar dose (Unden) and obtained seven pregnancies, mostly after one to two sterile matings. Mirskaya and Kedrov (36) treated 13 cows with estrogens but no pregnancies resulted.

ABSENCE OF HEAT, CAUSE NOT GIVEN

These cases of anaphrodisia may be due to ovarian hypoplasia or to persistent corpora lutea. Hancock (26) treated six cows with chorionic gonadotrophin and three conceived. Murray (39) used equine gonadotrophin (1,500 I.U.) in 19 cases, and 9 of these showed ovarian reaction. He also treated 35 cows with stilbestrol (20 mg.). Heat followed in a large proportion, but only one conceived. Glenney (24) also treated 12 with stilbestrol and two pregnancies resulted. Lentz (33) treated six with estrogens (folluetin) and four conceived.

NYMPHOMANIA

Nymphomania usually is treated by removal of the follicular cysts which cause the condition. In cases of long standing the cysts frequently have lost their lining of granulosa cells, and this presents a problem in hormonic treatment, since the rational hormonic therapy is to luteinize the follicles, thus breaking the deadlock in the cycle. Another complication may be the involvement of the central nervous system in the syndrome, as nymphomania is said to occur occasionally in the absence of large amounts of estrogens (Alba and Asdell, 1). An important paper on the condition and its treatment with hormones is that by Casida *et al.* (14). They point out that when extracts of sheep pituitary are injected the results differ with the site of injection. Subcutaneous injections produce follicular growth, while intravenous injections cause luteinization. Thus, the latter method is the one to be recommended in this particular form of therapy.

A wide variety of hormonic treatments have been attempted. Asdell (5) injected an extract of sheep pituitaries in four cases and obtained one conception. Walsh (56) injected twelve cows and seven conceived, while in two others normal cycles were restored. Casida *et al.* (14) made a very thorough test of this method using intravenous injections of sheep pituitary extract. They divided their cows into two groups of nymphomaniacs. Group 1 consisted of 71 cows which were nymphomaniac but without uterine complications. In 55 of them, corpora lutea formed, 52 showed normal heats and 46 were bred, with 32 pregnancies. Group 2 consisted of ten cows in which there were uterine complications. In this group, corpora lutea were formed in nine; normal heats followed in seven but none became pregnant. The only criticism which can be made is that many of the cows were in the incipient stages of nymphomania and the spontaneous recovery rate was not known. These workers also report that in 33 of the cows of group 1, cysts were ruptured, but that the degree of recovery in these cows did not differ from those in which the cysts were not ruptured. The total for this treatment is 97 cows injected, with 41 per cent of conceptions.

A luteinizing hormone, chorionic gonadotrophin, has been used by many workers. Koch (30) treated 35 cases and reported success in 30, with pregnancies in several. Niklas (41) treated 31 cows with 100 to 400 R.U. and had 20 cures, 11 of which were only temporary. He also reports treatment of 40, with 65 per cent conceptions. Haisch (25) treated nine cows and obtained six conceptions; Hancock (26) treated five with three conceptions; Deubler (18) had five injected cows and all conceived. Moore (37) treated 18; 12 ceased to be nymphomaniac, 10 had corpora lutea and 12 conceived. Teunissen (55) treated 12 cows and none conceived, while Durrell (20) records six treated, six conceptions. Lentz (33) used Folluetin and reported 16 conceptions in 17 cows injected. The total for this form of treatment is 112 cows of which 66 per cent conceived.

Teunissen (55) has used equine gonadotrophin in three cases, but none conceived.

Estrogen treatments also have been tried. Murphey *et al.* (38) treated one cow without success. Lentz (33) used stilbestrol in one case without success. Dancey (17) used the same substance on four cows; three improved and two conceived.

Progesterone has been used by Carlson (13), who recorded five pregnancies in five cases. Smith (49) treated ten cows and all symptoms disappeared. Bellomo (8) records the "effective" treatment of five cases with progesterone.

Durrell (20) has tried testosterone propionate in two cases without success.

One gains the impression from some of these reports that other forms of treatment than hormonal injections alone have been resorted to and this makes several of the most optimistic reports difficult to accept at their face value.

CYSTIC OVARIES WITHOUT NYMPHOMANIA

The exact significance of this classification is somewhat obscure. It may include cases in which the cysts occur in the corpora lutea or in the ovarian adnexa (mesovarium, parovarium). Spieler (51) treated 22 cows with an anterior pituitary extract and 77 per cent conceived. Casida *et al.* (14) used a similar treatment intravenously in 13 cases; nine produced corpora lutea, ten had normal heats and four conceived. Deubler (18) treated two cows with chorionic gonadotrophin and both conceived.

COWS WITH HEAT PERIODS BUT NO CONCEPTION

The type of cow in which heat periods are regular to irregular presents a most important problem, because they give the opportunity for breeding, but much time is wasted due to the delays in getting them pregnant. From the investigators point of view, they pose difficult problems, since, in the absence of obvious lesions, it is difficult to know when to begin treatment as sterile cases. Probably many of the cows with irregular heats represent a group of early aborters.

A further difficulty in assessing the results of treatment lies in the fact that in these cows their state of relative infertility may represent the degree of fer-

tility of the bull to some extent. A relatively infertile bull is not so successful with this class of cow as is a very fertile one. A rational hormonic method of treatment is not obvious, and many kinds of therapy have been attempted. In this class of infertility, controls are more essential, if that is possible, than in any other, and they rarely are found.

Spieler (51) treated 15 cows with an anterior pituitary extract and 93 per cent conceived. Asdell *et al.* (7) treated 11 cows with a sheep pituitary extract and four conceived. These cows had failed with previous estrogen treatment.

Eisenbach (21) used chorionic gonadotrophin in the small dose of 125 R.U. He reported that 12 cows were treated and all were cured. Bottomley *et al.* (11) treated 19 cows with 2,500 R.U. and obtained six pregnancies. In a group of cows in which difficulty was experienced in obtaining conceptions, the percentage of successful services was compared in treated and untreated cows. For the experimental cows services with treatment were 57 per cent effective, for untreated services 7 per cent, while for control cows, not deemed in need of treatment, services were 58 per cent successful. The authors draw the conclusion that treatment restored the average fertility to the level of the controls. Durrell (20) treated ten cows and four conceived.

Durrell (20) also has treated 24 cows with equine gonadotrophin, and 11 conceived to the first heat during or following therapy, a result which he interprets as showing the beneficial effects of the injections. He also treated three cows with equine gonadotrophin and progesterone and obtained one conception.

The value of estrogens has been studied by several workers. Murphey *et al.* (38) treated six cows with estrogens and four conceived. Frank (22) used ovarian extract (without corpora lutea) on 35 heifers and 90 per cent conceived. In 50 cows, about 90 per cent conceived to the first service and 10 per cent to the second. Zupp and Murphey (61) treated two cows without success. Spieler (51) used a complex mixture containing estrogens and obtained 93 per cent conceptions in 15 cows. Risse (47) used the same preparation (hormovilan) on 85 cows and reported 16 per cent conceptions. Asdell (5) used estradiol benzoate in eight cases and two conceived. Clark (16) treated 41 cows which had averaged 4.6 unsuccessful matings with a saline douche, and 38 conceived after an average of 1.9 further matings. He also used saline douches and injected an ovarian extract in 17 cases which had previously been treated with saline douches. Ten conceptions resulted in this group. Mirskaya and Kedrov (36) treated 11 cows with estrogens and only one pregnancy followed. Asdell *et al.* (7) injected 31 cows with estradiol benzoate and ten conceived. This is 32 per cent. Of 18 controls, 55 per cent conceived. The first group, as it is reported here, contained several cows which had failed to conceive as controls and which were treated subsequently. The average number of services per conception in the treated cows that became pregnant was 3.0, while in the control group (without treatment), 1.7 services were required. The evidence from this experiment neither supports the view that estrogens improve fertility nor that it lowers the number of services required per conception. In one field

test in which the cows treated were regarded as poor prospects, two of ten conceived. In another herd 17 cows were treated, 15 of them conceived but five aborted subsequently. Accuracy of diagnosis thus is an important factor in assessing results, especially in this type of infertility.

Durrell (20) treated four cows with progesterone and obtained one conception. Ruegg (48) fed testes to eight cows, seven became normal and four conceived. It is improbable that any hormone was absorbed by these cows.

At this stage, it hardly seems necessary to comment further upon this group of infertile cows.

OTHER CONDITIONS IN THE COW LEADING TO INFERTILITY

Metritis is a causal factor, or a contributory one, in many cases of infertility. Haisch (25) treated 25 cows with Lugol's solution together with injections of 25 R.U. of chorionic gonadotrophin. He states that 19 were cured. Spieler (51) treated seven cows with an anterior pituitary extract and six conceived. Anderson and Bugg (4) treated three with stilbestrol. One was improved and two not. Glenney (24) reports that stilbestrol has some effect in improving cows with pyometra.

Haisch (25) treated 23 cows suffering from vaginal prolapse with 250–1,000 R.U. of chorionic gonadotrophin and reports 17 cured and four others improved.

Stilbestrol has been recommended as an aid to the expulsion of the retained mummified fetus. Stuart (54) treated one cow with 25 mg., together with posterior pituitary extract. The fetus was expelled. One cow treated with stilbestrol alone failed to respond. Anderson and Bugg (4) also failed with one cow. Powell (45) tried one cow with chorionic gonadotrophin without effect; later she responded to stilbestrol. Murray and Robertson (40) treated one cow with stilbestrol without effect.

SEXUAL INACTIVITY IN BULLS

A good deal of work has been done on the use of various hormones upon sterility and sexual inactivity in bulls, but very little of it has been reported in the literature. In general, it may be said that, judging from results obtained with other species, when spermatogenesis ceases entirely the prognosis is unfavorable.

Pighini (43) treated eight bulls with anterior pituitary grafts and six became active again. Bottomley *et al.* (11) treated three bulls which produced semen with low sperm motility by injecting chorionic gonadotrophin and all were improved. Durrell (20) treated four bulls with low ability to mount with 300 mg. of testosterone propionate; all responded favorably, but in one the response was temporary. Reineke (46) treated 14 bulls with thyroprotein. Ten were improved in their libido, and conception rate improved in four of them.

GENERAL REMARKS

It has been a depressing task to bring the literature on the hormonic treatment of sterility together. Very little of the work is controlled adequately, and

much of it is anecdotal in character. The complications in work of this nature are such that it is difficult to devise critical experiments, but in view of the importance of sterility much more of this critical type of work should be done. Where adequate controls have been set up, hormonic treatment has failed to demonstrate efficacy. Another feature is that in any definite type of infertility the average percentage of response is about the same whatever the treatment. Such uniformity seems to show that the type of treatment with these boundaries means little; other factors leading to a fairly uniform rate of recovery are at work. These conclusions do not mean that hormonic treatment necessarily is worthless. They mean that we know too little about the exact rôle played by the hormones and about the dosages that should be employed. Much more groundwork needs to be done and many more critical field trials. Also, in field trials, the worker has tended to neglect the recommendations of the physiologist. He has worked on a shotgun basis without fitting the treatment, in most cases, to the type of infertility encountered.

REFERENCES

(1) Alba, J. de, and Asdell, S. A. Estrous Behavior and Hormones in the Cow. J. Comp. Psychol., 39: 119–123. 1946.

(2) Allen, G. S. Some Observations on Stilbestrol Dipropionate in the Treatment of Anoestrus. Vet. Record, 55: 168–169. 1943.

(3) Amilcare, P. Sulla Cura della Sterilita Bovine. Profilassi, 7: 347–350. 1934. (Animal Breeding Abs., 3: 361. 1935.)

(4) Anderson, G., and Bugg, R. R. Observations on the Use of Stilbestrol Dipropionate. Vet. Record, 54: 249. 1942.

(5) Asdell, S. A. Some Practical Applications of Endocrinology to Animal Husbandry. Am. Soc. Animal Production Proc., 28: 235–237. 1936.

(6) Asdell, S. A. Patterns of Mammalian Reproduction. Ithaca, N. Y., 1946.

(7) Asdell, S. A., Fincher, M. G., Smith, S. E., and Elliott, F. I. A Controlled Experiment to Restore Fertility in Dairy Cattle by Treatment with Gonadic and Gonadotropic Hormones. Cornell Univ. Ag. Expt. Sta. Mem. 243. 1942.

(8) Bellomo, G. Sull' Ormone del Corpo Luteo e sua Applicazione nella Terapia della Bovine Nimfomani. Riv. Milit. Med. Vet., 5: 83–88. 1942. (Animal Breeding Abs., 12: 76. 1944.)

(9) Bennewitz, G. Behandlung Ovariell bedingter Unfruchtbarkeit bei Kühen, Farsen und Stuten mit dem Follikel-hormonpräparat Progynon B. Diss., Hannover, 1936. (Animal Breeding Abs., 7: 201. 1939.)

(10) Bettini, U. Sull' Impiego del Prolan nella Cura della Sterilita nella Vacca e nella Cavalla Sostenuta da Lesioni Ovariche. Nuova Vet., 11: 500–503. 1933. (Animal Breeding Abs., 2: 89. 1934.)

(11) Bottomley, A. C., Folley, S. J., and Watson, H. M. S. Experiments on the Use of Chorionic Gonadotrophin (Pregnancy Urine Extract) for the Treatment of Sterility in Dairy Cattle. J. Agr. Sci., 30: 235–243. 1940.

(12) Cameron, H. S. Clinical Observations on the the Use of Equine Gonadotropin in the Mare and Cow. J. Am. Vet. Med. Assoc., 100: 60–62. 1942.

(13) Carlson, E. R. Functional Sterility in Cattle. Cornell Vet., 30: 427–436. 1940.

(14) Casida, L. E., McShan, W. H., and Meyer, R. K. Effects of an Unfractionated Pituitary Extract upon Cystic Ovaries and Nymphomania in Cows. J. Animal Sci., 3: 274–282. 1944.

(15) Casida, L. E., Meyer, R. K., McShan, W. H., and Wisnicky, W. Effects of Pituitary

Gonadotropins on the Ovaries and the Induction of Superfecundity in Cattle. Am. J. Vet. Research, 4: 76–94. 1943.

(16) CLARK, C. F. Clinical Results in the Treatment of So-called Functional Sterility of Cows. J. Am. Vet. Med. Assoc., 90: 488–492. 1937.

(17) DANCEY, J. C. Practical Experiences with Dibestranol D. P. Can. J. Comp. Med. and Vet. Sci., 9: 23–25. 1937.

(18) DEUBLER, E. C. Antuitrin S in the Treatment of Cystic Ovaries of Cows and Mares. Vet. Ext. Quart., Univ. Penn., 89: 31–39. 1943.

(19) DEUBLER, E. C., AND BARNES, M. F. Sterility in Cattle. J. Am. Vet. Med. Assoc., 61: 254–258. 1922.

(20) DURRELL, W. B. Observations on Sterility in Dairy Cattle and the Use of Natural and Synthetic Hormones. Can. J. Comp. Med. and Vet. Sci., 11: 290–297. 1947.

(21) EISENACH, F. A. Zwei Jahre 'Prolan' im Kampfe gegen die Sterilität der Rinder. Wien. tierärztl. Monatsschr., 22: 202–204. 1935.

(22) FRANK, E. R. The Role of Ovarian Extract in Bovine Sterility. Cornell Vet., 24: 75–79. 1934.

(23) FREI, W., AND STÄHELI, A. Über Anaphrodisie bei Kühen. Deut. tierärztl. Wochschr., 34: 755–760. 1926.

(24) GLENNEY, W. C. Stilbestrol in Dairy Practice. North Am. Veterinarian, 25: 91–96. 1944.

(25) HAISCH, A. Versuche mit Prolan in Oel bei Konstitutionell bedingter Sterilität des Rindes, insbesondere bei Unterentwicklung der Ovarien, Nymphomanie, Metritis und Scheiderworfall. Berlin u. Münch. tierärztl. Wochschr., 46–47. 1944.

(26) HANCOCK, J. L. Clinical Observations on the Use of 'Luteinizing' Hormone (Chorionic Gonadotrophin) in the Treatment of Ovarian Cysts in the Bovine. Vet. Record, 59: 639–641. 1947.

(27) HUPKA, E., AND MAJERT, W. Ueber die Einwirkung des Prolan auf Eierstock und Euter bei Haustieren und über seine Eignung zur Bekämpfung der Sterilität dieser Tiere. Deut. tierärztl. Wochschr., 40: 614–616. 1932.

(28) JENSEN, G. M. Ufruglbarketsbehandling hos Koaeget specielt med Henblek paa Hormonpreparaters Avendelighet. Medeenskl. Danske. Dyrl., 15: 4. 1941. (Animal Breeding Abs., 14: 20–21 1946.)

(29) KEDROV, V. Causes of Infertility in Cows and Measures for its Elimination. Dokl. Akad. Selzkohoz. Nauk. Lenin., 1–2: 34–39. 1945. (Animal Breeding Abs., 14: 83. 1946.)

(30) KOCH, W. Die Hormonbehandlung der Nymphomanie des Rindes. Tierärztl. Rundschau, 43: 451–454. 1937.

(31) KOCH, W. Hormonbehandlung der Ovaryhypoplasie nach Maul- und Klauenseuche. Vorläufige Mitteilungen. Berlin u. München tierärztl. Wochschr., 576–577. 1938.

(32) KÜPPER, P. Über die Wirkung des Follikel-hormonpräparates 'Unden' auf den Weiblichen Geschlechtsapparat des Rindes bei Anaphrodisie. Diss., Hannover, 1938. (Animal Breeding Abs., 8: 128. 1940.)

(33) LENTZ, W. J. Hormonal Therapy in Cystic Ovaries of Cows. Vet. Ext. Quart., Univ. Penn., 95: 8–17. 1944.

(34) MCSHAN, W. H., AND MEYER, R. K. The Preparation and Properties of Pituitary Follicle-stimulating Fractions made by Trypsin Digestion. J. Biol. Chem., 135: 473–482. 1940.

(35) MENZANI, C. Sull' Impiego degli Ormoni Sessuali Preipofisari ('Prolan') nel Trattamento dell' Ipofunzione Ovarica nella Bovine. Nuova Vet., 12: 240–243. 1934. (Animal Breeding Abs., 3: 21–22. 1935.)

(36) MIRSKAJA, L. M., AND KEDROV, V. K. Can Estrogens Restore Fertility in Cows? Vestn. Zivotn., 1: 74–84. 1945. (Animal Breeding Abs., 15: 174. 1947.)

(37) MOORE, G. R. Effects of Chorionic Gonadotropin on Cystic Ovaries in the Cow. Vet. Med., 41: 163–164. 1946.

(38) MURPHEY, H. S., MCNUTT, G. W., ZUPP, B. A., AND AITKEN, W. A. Case Reports on the Use of Oestrual Hormone and Other Gland Extracts in the Treatment of Functional Sterility. 7th Rept. J. Am. Vet. Med. Assoc., 68: 443–450. 1926.

(39) MURRAY, J. G. Notes on the Subject of Infertility in Cattle. Vet. Record, 55: 323–326. 1943.

(40) MURRAY, J. G., AND ROBERTSON, R. R. Treatment for Expulsion of Mummified Foetus. Vet. Record, 54: 484. 1942.

(41) NIKLAS, F. A. E. Beitrag zur Anwendung des Prolan in öliger Aufschwemmung. Berlin. tierärztl. Wochschr., 54: 283. 1938.

(42) PATAKI, P. Organotherapie im Kampfe gegen die Sterilität. Münch. tierärztl. Wochschr., 86: 15–17. 1935.

(43) PIGHINI, G. Iniezioni ed Innesti di Ipofisi Anteriore in Animali Iposessuali e Senili. Nuova Vet., 11: 446–458. 1933. (Animal Breeding Abs., 2: 90. 1934.)

(44) POWELL, C. R. A. Successful Ejection of a Mummified Foetus. Vet. Record, 54: 137. 1942.

(45) RATTI, P. Die Provetanbehandlung der Sterilität beim Braunvieh (Bergell). Schweiz. Arch. Tierheilk., 79: 324–326. 1937.

(46) REINEKE, E. P. The Effect of Synthetic Thyroprotein on Sterility in Bulls. In, The Problem of Fertility, E. T. Engle, Ed. Princeton. 1946.

(47) RISSE, W. Behandlung der Unfruchtbarkeit mit Standardisiertem Weizenkeimöl (Vitamin E) und Hormovilan bei Rindern. Diss., Hannover. 1936. (Animal Breeding Abs., 7: 220–221. 1939.)

(48) RUEGG, J. Über Versuche, den Antagonismus der Weiblichen und Männlichen Keimdrüsen Therapeutisch zu Verwenden. Schweiz. Arch. Tierheilk., 76: 2–12. 1934.

(49) SMITH, C. L. Nymphomania in Dairy Cattle Treated with Corpus Luteum Extract. Vet. Med., 36: 530. 1941.

(50) SMITH, P. E., ENGLE, E. T., AND TYNDALE, H. H. Differential Ovarian Responses after Injections of Follicle-stimulating and Pregnancy Urine in Very Young Female Rats. Proc. Soc. Exptl. Biol. Med., 31: 744–746. 1934.

(51) SPIELER, H. Behandlung der Unfruchtbarkeit bei Rindern mit Hormovilan. Tierärztl. Rundschau, 41: 326–327. 1935.

(52) STÄHELI, A. Über Eierstocksimplantationen bei Praesenilen Kühen. Festschr. zum siebzigsten Geburtstage von Herrn Prof. Dr. E. Zschokke in Zürich, 85–92. 1925.

(53) STEINACH, E., STÄHELI, A., AND GRÜTER, F. Behebung der Sterilität bei Landwirtschaftlichen Nutztieren (Rinder, Kühe, Schweine) durch das Weibliche Sexualhormon. Wien. klin. Wochschr., 47: 129–132. 1934.

(54) STUART, K. Two Cases of Mummified Foetus Treated with Stilbestrol. Vet. Record, 54: 106. 1942.

(55) TEUNISSEN, G. H. B. Anaphrodisie bij het Rund in het Bijzonder Betreffende de Resultaten van de Behandeling met Gestyl. Tijdschr. Diergeneesk., 71: 510–517. 1946.

(56) WALSH, F. E. Dysfunction of the Ovary. J. Am. Vet. Med. Assoc., 101: 404–410. 1942.

(57) WRIGHT, L. G. Observations on the Clinical Aspect of Reproductive Disorders in Cattle. Vet. Record, 57: 313–320. 1945.

(58) ZAVADOVSKII, B. Utilization of P.M.S. for the Control of Infertility in Cows. Sovkoz. Prozvod., 6: 29–33. 1945. (Animal Breeding Abs., 14: 84. 1946.)

(59) ZAWADOWSKY, M., AND ESKIN, I. New Data on the Regulation of the Sexual Cycle in the Cow. Bull. Biol. Med. Exptl. U.S.S.R., 4: 200–202. 1937. (Animal Breeding Abs., 7: 122. 1939.)

(60) ZOLLINGER, M. Über Behandlung der Sterilität des Rindes mit Provetan-Schering und Stilbestrol-Roche. Diss., Zürich, 1946. (Animal Breeding Abs., 15: 176. 1947.)

(61) ZUPP, B. A., AND MURPHEY, H. S. Study of the Phenomena of Oestrus and Reproduction in Domestic Animals with Case Reports. (8th Dept.) Vet. Med., 21: 261–264. 1926.

NUTRITION AND THE TREATMENT OF STERILITY IN DAIRY CATTLE: A REVIEW*

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The relation between nutrition and infertility in dairy cattle is a difficult one to review because it has so many ramificatons. The direct literature is rather scanty compared with that upon the same subject in laboratory animals; much may be gathered by inference but little can be substantiated by reference to critical work. Malnutrition may affect the reproductive system in a variety of ways, directly, and indirectly, and it may take a wide variety of forms. Under practical conditions, one rarely finds a clear case of malnutrition due to a deficiency of one factor in the feed. The usual condition found is that in which a multiple deficiency exists. Underfeeding may be accompanied by poor quality of the feed; thus, an energy deficiency often is complicated by deficiencies in protein, phosphorus and vitamin A. A protein deficiency often is accompanied by a phosphorus deficiency, and a vitamin A deficiency by a protein and phosphorus deficiency. When a specific deficiency leading to reproductive disorder is found, treatment consists of a review of the feeding picture and the application of common sense methods in providing better feed.

Malnutrition usually results in lowered vitality so that it is reasonable to assume that any form of malnutrition lessens the resistance to disease. This is one of those general statements that is very difficult to prove on an experimental basis. Attempts to prove it for the reproductive tract have been very few and they have led to negative or inconclusive results. When disease has once made inroads in an animal or herd, the problem is no longer the simple one of correcting feed conditions; the disease factors must be attacked and eliminated, as they are not only troublesome in themselves, but the affected animals are reservoirs which threaten the health of the other members of the herd.

In discussing the problems of reproduction with farmers, the writer always has stressed the fact that a healthy herd is more profitable, both in production and reproduction, than an unhealthy one, and that it is better to maintain a herd in good health by adequate feeding than it is to attempt to restore a herd that has been let down by malnutrition. When this stage has been reached, the problem is no longer the simple one of providing adequate feed. The fact that adequate feed is cheaper than attempts to restore deficiencies by reinforcing an inadequate dietary regime with proprietary articles also has been stressed.

In general, it has been shown for many deficiencies that the young animal is more susceptible than is the adult. Early malnutrition prevents the orderly growth of the reproductive organs as a physiologically integrated system. When this occurs, it is difficult, and sometimes impossible, with our present knowledge, to initiate the correct balance for proper development. Once reproduction has

* Based upon a paper presented in the symposium on Reproductive Problems of Dairy Cattle at the 43rd Annual Meeting.

begun the problem is easier, as it then is a question of maintaining in smooth operation an organization which already has been built up. The mature animal is more resistant, also, because it has reserves to draw upon which are not available to the growing animal. For these reasons, the writer believes that more attention should be paid to the nutrition of the growing animal, both male and female. Prevention rather than cure should be the keynote of our advisory and research work.

Specific dietary deficiencies rarely cause specific lesions in the reproductive tract. They usually produce general effects leading to a variety of types of infertility or of disease. Therefore, in this review the approach is to consider the food factors individually and to point out the types of failures that have been observed, together with the conditions under which deficiencies may occur. It is not feasible to classify by considering the individual functions of the reproductive organs. No attempt is made to review the relations between deficiency diseases and reproduction as a whole. Attention is centered upon the knowledge we possess of the subject as it relates to dairy cattle.

During the past few years, many attempts have been made, particularly in the management of bulls used for artificial insemination, to reinforce, in a variety of ways, rations usually considered adequate. These reports have been, in the main, negative, but Smirnov-Ugrjumov and Laptev (48) found that the addition of animal protein improved semen quality. However, Branton *et al.* (7) failed to find any benefit on semen quality or fertility when they used skim milk powder as the principal protein in a 15 per cent supplement. On the other hand, they also found that a poor protein, corn gluten feed, was without deleterious effect.

In interpreting results, the time factor is important, especially in bulls. It takes about 3 weeks for complete spermatogenesis and about 3 weeks more for transit through the epididymis, while sperm retain their fertilizing power when stored in the epididymis for a maximum of about 40 days. In view of these facts, it is unlikely that a deficient diet which causes a sudden break in spermatogenesis will have its full effect upon semen ejaculates and on fertility for several weeks after the break occurs. Aristotle (2) was led to deny that the testis had a direct bearing on fertility, because he had noticed that a certain bull did not lose his fertility immediately after castration.

GENERAL INANITION

It generally is believed that when calves are underfed they are late in attaining puberty, but there is little precise data on the subject. In fact, the average age of puberty for heifers under normal conditions never has been worked out with statistical detail, so that no "yardstick" exists by which comparisons might be made. There is a certain amount of anecdotal lore concerning the effects of underfeeding on the age of puberty, but, while most of this has a basis in fact, we probably are dealing with deficiencies of a multiple nature rather than with a straight energy deficiency. Richter (43) pointed out that heifers

were late coming in heat after the underfeeding which occurred during World War I, and Moehl (33) has reported in much the same vein. Eckles (12) records that heifers fed heavily experienced their first heat earlier than did those fed lightly; the difference for Jerseys was 65 days, for Ayrshires, 100 days, and for Holsteins, 126 days. That underfed heifers are late experiencing their first estrus also has been recorded by Allen (1) in England. The condition often shows itself towards the end of an unusually severe winter and is corrected when the heifers are placed on spring pasture. Quinlan (41) has reported similarly from South Africa. In older animals, under-nutrition results in irregular heat periods and low fertility (Richter, 43; Dolder, 11).

In bulls, Jones *et al.* (24) reported that calves fed after 5 to 7 months of age on alfalfa hay and minerals grew at a rate which was 10 to 15 per cent below normal. They did not produce good semen of normal fertility until they were 2 to 3.5 years old, while others fed likewise, but with the addition of skim milk powder, performed efficiently after they were 1 year old. They ascribed the difference in the two groups to a difference in energy intake.

There appears to be no data from dairy cattle dealing with specific deficiencies of protein, carbohydrate or fat.

MINERAL DEFICIENCIES

The usual deficiency met with in the field is a phosphorus deficiency. It tends to occur when diets low in protein are fed, under conditions more or less resembling those found on the range when the grass is dry or when the soil definitely is deficient in phosphorus, and in borderline areas, when the cows are lactating but are not fed an adequate protein and mineral supplement. Generally, reproduction does not appear to suffer until the animal shows clinical symptoms of phosphorus deficiency, *e.g.* unthriftiness, rough coat and depraved appetite. Tuff (53) reported reduced fertility in dairy cattle in certain areas of Norway in one of the earlier thorough studies devoted to this problem. Eckles *et al.* (13) studied conditions in affected areas in Minnesota. They reported that there was considerable breeding trouble; on many farms not more than one calf was obtained every 2 years, but there was not more than the usual amount of abortion. Heifers sometimes did not come in heat until they were past 2 years old. The condition was most severe in late winter and early spring, especially following a dry summer and fall. One cow which was killed had subnormal ovaries, and palpation showed this condition to be general. Phosphate supplements cured the condition; cows ovulated and the normal number of conceptions occurred. Analyses showed that phosphorus was low in the feeds grown on affected farms, but the calcium content was normal. In a further study, Eckles *et al.* (14) stated that cows which were affected tended to have one or two heat periods after they calved. If they became pregnant at this time, the calves were carried to term; if not, they tended to show anestrum for the rest of their lactation; after they were dried off, heat periods returned and they had a normal chance of conception. In this connection, Derivaux (10) found that neither phosphorus nor calcium deficiencies affected the corpus luteum. Palmer

et al. (38), in an experimental study, found delayed first heats in heifers. Later, ovulations without heats occurred at normal intervals. The life of the corpus luteum was normal. Conception occurred with relative ease but parturition tended to be difficult and four of the eleven calves were either weak or dead at birth. This was an extreme case of phosphorus and protein deficiency, and the cows were about 50 per cent underweight.

Riddell *et al.* (44) also report absence of heats in cows on a phosphorus-deficient ration.

In South Africa, Quinlan *et al.* (42) found that the average age at first heat in 28 heifers fed dry rations and restricted in exercise was 528 days. When cycles were established, their length was normal. The deficiency here may be due to vitamin A lack and not to phosphorus. Theiler *et al.* (50) previously had reported a calf crop of 51 per cent in phosphorus-deficient herds, and this was restored to 80 per cent in herds with a phosphate supplement.

Webster (57) reported that in phosphorus deficient (Waihi disease) areas of New Zealand the calf crop was 63.7 per cent in pika herds and 68.2 per cent in no pika herds; this was not a very large difference, but supplements were being fed in many of the pika herds. The chief reproductive symptom was absence of heat periods, and three cases at autopsy had subnormal ovaries. He found a correlation of +0.45 between the phosphorus content of spring pasture and the breeding efficiency index. The correlation between the latter and calcium content was –0.35, and for the Ca : P ratio it was +0.51. The correlations with autumn pasture were much lower. Phosphorus was not really low on any of the farms studied. Farms above the mean in Ca : P ratio had a breeding efficiency index of 1.6, while those below the mean had an index of 1.3.

It appears, therefore, that phosphorus deficiency interferes with ovarian function, causing probably a lowered estrogen secretion in the early stages. In more severe conditions, follicular development is interfered with. If pregnancy occurs, little effect is seen until the end of gestation, when parturition may be difficult and the calves may be born weak or dead. The deficiency occurs where phosphorus in the soil and rations is low, and it may only become apparent in borderline cases when the drain of phosphorus through lactation is rather heavy. Work is needed on the anterior pituitary to see whether the effect is through this organ or directly upon the ovary.

The phosphorus requirement for reproduction is about 10–12 g. per day. This is not above the requirement for growth but decidely below the additional amount needed if the cow is lactating (Huffman *et al.*, 23).

In connection with the reports that once pregnancy is initiated it is not interrupted, it is interesting to note that Hart *et al.* (18) found that contagious abortion was no more frequent in a herd receiving poor rations without minerals than in one in which the rations were good and were reinforced with mineral supplements.

There is no evidence that a calcium deficiency causes reproductive failure in dairy cattle (Palmer *et al.*, 37; Huffman, 22). Trace elements also have not been incriminated as yet.

Iodine deficiency apparently does not impair the reproductive function in itself, so far as is known for dairy cattle in practice. It does, however, cause the birth of premature, weak or dead calves. According to Kalkus (25), the danger is greater in a prolonged winter and if the calves are born in a cold spell. Keith (26) has reported in much the same vein. The danger may arise in the Sierra region and in that of the Great Lakes.

VITAMINS

Vitamin A deficiency has been reported frequently in range cattle when they have been on dry feed or dried up range for some time. One such report is that of Hart and Guilbert (19). They include among the symptoms the birth of dead or weak calves with frequent retention of the placenta. The condition somewhat resembles that which is associated with brucellosis. The cows which produce these calves usually exhibit typical symptoms of vitamin A deficiency to some degree. Such symptoms are night blindness, ophthalmia and diarrhea. Lack of condition also is frequently noticed. These workers ascribe similar reproductive failures observed by others on diets consisting entirely of certain plants, such as wheat, oats or corn, to a lack of this vitamin. They also consider that similar failures, observed when cottonseed meal is fed, are due to the destruction of vitamin A. Meigs and Converse (31) have observed these symptoms in dairy cows fed dry rations. There is no evidence that estrous cycles are interfered with in either beef or dairy cattle. Thus, Davis and Madsen (9) obtained conceptions in beef cattle receiving less than 60 μg. of carotene per kg. body weight. This amount was insufficient to prevent the development of typical lesions. They performed a post-mortem examination on one heifer that had aborted at 8 months and found that she had "infantile" ovaries and a cystic pituitary. The condition of the corpus luteum apparently has not been investigated.

Conception may not occur as readily in vitamin A deficient cows, as Axelsson (4) reports that cows kept for 3 months before service on a diet containing 27–47 mg. of carotene required 2.0 matings per conception; those fed 48–72 mg. required 1.4, and those above 72 mg. required 1.2 matings.

Vitamin A deficiency in bulls has received considerable attention. Sutton *et al.* (49) kept calves on a low vitamin A diet until they were a year old. They observed degeneration of germinal epithelium and absence of spermatozoa. The alpha cell zone in the anterior pituitary was extended, but, nevertheless, there was an increase in gonadotrophic potency of the tissue. Fluid had accumulated in the cleft of the pituitary. Hodgson *et al.* (21) kept 12 bulls on a diet which provided a low intake of this vitamin. Seven remained fertile though they would not mount in many cases. The semen was low in spermatozoan concentration, the count of abnormal sperms was high, the pH was higher than usual and the semen did not store well. They remarked that gross symptoms of deficiency appeared before reproductive function began to suffer. If the deficiency was produced before the onset of puberty, the bulls failed to breed at all. Their pituitaries were cystic and the epithelium of the seminiferous tubules was de-

generating. The addition of vitamin A to the diet did little to improve the reproductive organs once these lesions had appeared. Erb *et al.* (15) also found that vitamin A deficiency delayed puberty, decreased sex drive and reduced the amount of spermatogenesis. The anterior pituitary was edematous, and there were histological changes in the adrenal cortex. It was found that the sexual disorders continued long after the addition of adequate amounts of vitamin A to the diet. In both these papers, it was stated that gross symptoms preceded involvement of the reproductive organs. A film prepared by Bratton at Cornell shows that ability to mount cows is lost before semen production and fertility suffer to any marked extent.

Remarkable results have been claimed for the use of vitamin C (ascorbic acid) in the treatment of failures in reproduction, but so far the method has not been submitted to a critical test. In view of the fact that the greatest degree of success has been claimed in cases with regular cycles but without obvious pathology, and that it is in this class that spontaneous recoveries are most frequent, the need for adequate controls is obvious, but one does not find them. The writer's experiences with hormones, both in his own work and through the literature causes him to reserve judgment until critical data are available for study.

Phillips *et al.* (39) found that normally there is a rise in blood plasma ascorbic acid during mid-to-late heat. Of seven poor breeders, two failed to show this rise. Eleven cows with regular cycles or with a tendency to omit heats were injected with this vitamin. Ten of them conceived to the first service. In three cows which lacked uterine tone and in three with cystic ovaries, the cows failed to respond to the injections. These workers quote a communication from Brown who injected twelve cows and obtained seven or eight conceptions. McIntosh (30) advises the injection of 1.5 to 2 g. of ascorbic acid per 1000 lb. live weight. He cites a communication which he had received in which, of 33 cows with regular heats which had been injected, 31 conceived. Of six with irregular heats, four conceived, while no response was obtained in eight cows with cystic ovaries. Barker (5) records the case of one cow which conceived in 2 consecutive years on the day on which the vitamin was injected and three in which it was ineffective. It may be mentioned that average diestrous plasma ascorbic acid levels in 82 cows have been obtained by Asdell *et al.* (3). These cows required from one to six services per conception or failed to conceive after six services. No relationship was found between the ascorbic acid level and the ease of conception.

Injections of ascorbic acid are said to be equally effective in the treatment of infertility of the bull. Phillips *et al.* (40) treated 29 bulls with poor breeding records by injecting 1.5 g. of ascorbic acid per 1000 lb. live weight each week. Four failed to respond, and one of these had atrophic testes. The semen changed in consistency from a thin watery fluid to thick and creamy. The spermatozoa were increased in their longevity. Six of these bulls had little sex interest in cows and all were improved after the injections. These workers also found that in cases in which the ascorbic acid in the semen was below 2 mg. per 100 ml. the

bulls were poor breeders, from 2 to 8 mg. their record was satisfactory, while for those in which the level was above 8 mg. the breeding records were erratic.

One method of increasing the ascorbic acid level in the blood is by feeding chloretone. Scheidenhelm *et al.* (46) have used this method with three bulls which had poor records. In each of them the number of services needed to obtain conceptions was improved very markedly.

It is possible that vitamin D deficiency is a factor in bovine infertility. Wallis (56) reports a decline in general health when this substance is lacking in sufficient quantity and records that four cows on such a diet did not experience heat periods.

The problem of vitamin E need for adequate reproduction in cattle is a difficult one to review because so many extravagent claims have been made for the use of this compound. Usually these reports have dealt with the addition of the vitamin in the form of wheat germ oil or sprouted oats.

In 1931 Vogt-Muller and Bay (55) reported that they treated 12 cows, which did not conceive readily, by injecting 10 cc. of wheat germ oil intramuscularly. All conceived after the treatment. Later, Bay and Vogt-Muller (6) reported the treatment of 70 cows with 49 conceptions. Eisse (45) treated 60 cows but only 10 conceived in 4 to 6 weeks after treatment. It had no effect at all on young and old cows with ovarian atrophy, persistent corpora lutea and follicular cysts. Koenen (27) reported some favorable results, but not enough to indicate that wheat germ oil is a specific remedy for infertility. Tutt (54) used wheat germ oil in 25 cases of infertility due to various conditions and obtained 17 conceptions. However, all these cases were undergoing other treatments at the time of injection, mainly in the form of douches with Lugol's solution. In this connection, and also in connection with ascorbic acid therapy, one must note that Clark (8) treated 41 cows which had averaged 4.6 unsuccessful matings with a saline douche, and that 38 of them conceived after an average of 1.9 further matings. Schweizer (47) fed vitamin E to 19 cows that failed to conceive for no apparent reason and 13 conceived. McIntosh (29) reports that of 57 cows treated with wheat germ oil 38 conceived at their first subsequent service. No details are given. Moussu (35) states that wheat germ oil prevents losses due to contagious abortion. It was given in 30–40 cc. doses at conception, at 3 and 6 months. In a district where 7,000 cows were thus treated, "to-day the success is regular and everywhere one sees abortions, non-deliveries and mortality of the new-born disappear".

On the other side of the picture is the report by Gullickson *et al.* (16) that nine heifers were raised on vitamin E-free rations and that all calved normally.

On the use of wheat germ oil for bulls, there are the reports by Timin and Pereturina (51, 52) of 5 bulls which were receiving steppe hay and concentrates. These rations were reinforced with 500 to 1200 g. of wheat embryos. Sexual activity improved, semen volume increased 18 per cent, sperm numbers increased 11 per cent and activity increased 14 per cent. Gullickson *et al.* (16) reported that two bulls fed a vitamin E-free ration were fertile. In five others raised on similar rations, the sexual development was normal.

Harris *et al.* (17) have used a vitamin E concentrate of mixed tocopherols. They report that in one herd a number of cows which had averaged five services per conception in previous years had a service rate of less than three in a year during which either the tocopheral supplement, or one containing this supplement together with vitamin A, was fed. The record for the previous year showed three stillbirths, four abortions, and retained placentas requiring the services of a veterinarian after the birth of almost every calf. In the year of supplementation, no stillbirths, one abortion and one retained placenta were recorded.

Moore (34) used sprouted oats on four heifers that did not conceive readily. Two conceived during the experimental feeding period. Miller and Graves (32) used 115 heifers and cows. Of these, 27 conceived before they were fed sprouted oats, 57 conceived during or after the treatment and 31 did not. Henke (20), in a thorough experiment with controls, did not find that sprouted oats were of benefit. He had one group of four heifers which had not come in heat at all. Two were fed sprouted oats and both conceived, though one did not until a year after the feeding had been stopped. Two were not fed sprouted oats and one conceived. Another group consisted of 19 cows that were slow in coming in heat after calving. Of nine fed the oats, all conceived. Of ten not fed in this manner, nine conceived. Each group averaged 2.2 services per conception, but the fed group averaged 268 days from calving to conception and the control group 229 days. Another group consisted of cows bred once without conception. Twenty-seven were fed sprouted oats, and 20 (74 per cent) conceived with a service rate of 3.4 for those that became pregnant. Of 25 controls, 18 (72 per cent) conceived with a service rate of 4.2.

OVERFEEDING AND FERTILITY

It generally is believed that overfat cows have more difficulty in conceiving than do others. This belief has not been submitted to experimental test, and it may be argued that the tendency to fatten readily denotes an inherent endocrine imbalance which would, in itself, impair fertility.

There is a certain amount of supporting evidence for the idea that sterility may result from over-fatness. Marshall and Peel (28) examined the reproductive tracts of seven heifers and cows that were fat and sterile. In all of them, there were fatty deposits in the ovaries, few follicles and an unusually large amount of orange pigment in the stroma. Quinlan (41) in a series of fat cows, found that the ovaries were smaller than usual, but that they were normal except for the absence of large follicles. Newton (36) stated that in quick-fattening breeds in Argentina fatness is a frequent cause of sterility. Cows suffering from the condition had fatty deposits in the bursa ovarii which prevented its close application to the ovary. This could be detected by rectal palpation, and the cows in which it was present were not excessively fat to the eye. However, it does not follow that fat sterile cows are sterile because they are fat.

The writer considers that this review demonstrates the need for adequately controlled experiments in this field, just as much as they are needed in the

hormone and infertility field. Much, too, is to be gained if the biochemist or nutritionist works closely with the physiologist. Far too little is known regarding the manner in which feed deficiences affect the complex functions of the reproductive organs.

REFERENCES

(1) ALLEN, G. S. Some Observations on Stilbestrol Dipropionate in the Treatment of Anoestrus. Vet. Record, **55**: 168–169. 1943.

(2) ARISTOTLE. De Generatione Animalium. Ed. by A. Platt. Oxford. 1910.

(3) ASDELL, S. A., CUPPS, P. T., HARRISON, E. S., LOOSLI, J. K., SMITHCORS, J. F., AND FINCHER, M. G. Unpublished work.

(4) AXELSON, J. Karotintillförselns Betydelse für Nötkreaturens Fruktsamhet. Lantmannen, **31**: 37–39. 1947.

(5) BARKER, C. A. V. Experience with Ascorbic Acid Therapy for Sterility in Cows. Can. J. Comp. Med., **8**: 192, 195. 1944.

(6) BAY, F., AND VOGT-MULLER, P. Continued Studies on Treatment of Sterility in Cows and Breeding Sows with Wheat Germ Oil (Vitamin E). Vet. J., **90**: 288–290. 1934.

(7) BRANTON, C., BRATTON, R. W., AND SALISBURY, G. W. Personal Communication. 1948.

(8) CLARK, C. F. Clinical Results in the Treatment of So-called Functional Sterility in Cows. J. Am. Vet. Med. Assoc., **90**: 488–492. 1937.

(9) DAVIS, R. E., AND MADSEN, L. L. Carotene and Vitamin A in Cattle Blood Plasma with Observations on Reproductive Performance at Restricted Levels of Carotene Intake. J. Nutrition, **21**: 135–146. 1941.

(10) DERIVAUX, J. Le Corps Jaune Persistant chèz la Vache. Ses Rapports avec le Metabolisme Phospho-calcique. Ann. méd. vét., **85**: 298–311. 1941.

(11) DOLDER, —. Heilversuche beider Anaphrodisie des Rindes durch Injektion von Ovarialextrakten. Diss. Zurich. 1926.

(12) ECKLES, C. H. Dairy Cattle and Milk Production, New York. 1920.

(13) ECKLES, C. H., BECKER, R. B., AND PALMER, L. S. A Mineral Deficiency in the Rations of Cattle. Minn. Agr. Expt. S Bull. 229. 1926.

(14) ECKLES, C. H., GULLICKSON, T. W., AND PALMER, L. S. Phosphorus Deficiency in the Rations of Cattle. Minn. Agr. Expt. Sta. Tech. Bull. 91. 1932.

(15) ERB, R. E., ANDREWS, F. N., HAUGE, S. M., AND KING, W. A. Observations on Vitamin A Deficiency in Young Dairy Bulls. J. Dairy Sci., **30**: 687–702. 1947.

(16) GULLICKSON, T. W., PALMER, L. S., BOYD, W. L., AND OLSON, F. C. Vitamin E in the Nutrition of Cattle. J. Dairy Sci., **27**: 634. 1944.

(17) HARRIS, P. L., SWANSON, W. J., AND HICKMAN, K. C. D. Co-vitamin Studies VI. Effect of Tocopherol Supplementation on the Output of Vitamin A, Carotene and Fat by Dairy Cows. J. Nutrition, **33**: 411–428. 1947.

18) HART, E. B., HADLEY, F. B., AND HUMPHREY, G. C. The Relation of Nutrition to Contagious Cattle Abortion. Wis. Agr. Expt. Sta. Research Bull. 112. 1932.

(19) HART, G. H., AND GUILBERT, H. R. Vitamin Deficiency as Related to Reproduction in Range Cattle. Calif. Agr. Expt. Sta. Bull. 560. 1933.

(20) HENKE, L. A. Results of Feeding Sprouted Oats to Correct Sterility in Cattle and Swine. J. Agr. Research, **51**: 51–59. 1935.

(21) HODGSON, R. E., HALL, S. R., SWEETMAN, W. J., WISEMAN, H. G., AND CONVERSE, H. T. The Effect of Vitamin A Deficiency on Reproduction in Dairy Bulls. J. Dairy Sci., **29**: 669–687. 1946.

(22) HUFFMAN, C. F. Roughage Quality and Quantity in the Dairy Ration: A Review. J. Dairy Sci., **22**: 889–980. 1939.

(23) HUFFMAN, C. F., DUNCAN, C. W., ROBINSON, C. S., AND LAMB, L. W. Phosphorus Requirement of Dairy Cattle when Alfalfa Furnishes the Principal Source of Protein. Mich. Agr. Expt. Sta. Tech. Bull. 134. 1933.

(24) JONES, J. R., DOUGHERTY, R. W., AND HAAG, J. R. Relation of Nutrition to Growth and Breeding Performance in Dairy Bulls. J. Dairy Sci., 28: 311–320. 1945.

(25) KALKUS, J. W. A Study of Goitre and Associated Conditions in Domestic Animals. Wash. Agr. Expt. Sta. Bull. 136. 1920.

(26) KEITH, —. In CAMERON, A. T. Recent Advances in Endocrinology. 3rd Ed. Philadelphia. 1936.

(27) KOENEN, H. Behandlung der Anaphrodisie und des Umrinderns bei Kühen und Färsen mit dem Waisenkeimöl "Evion" (E-Merck). Vet. Med. Diss., Hannover. 1938. (Animal Breeding Abs. 9: 16. 1941.)

(28) MARSHALL, F. H. A., AND PEEL, W. R. "Fatness" as a Cause of Sterility. J. Agr. Sci., 3: 383–9. 1910.

(29) MCINTOSH, R. A. Breeding Problems. Can. J. Comp. Med. 4: 342–347. 1940.

(30) MCINTOSH, R. A. Ascorbic Acid (Vitamin C) in the Treatment of Impotency in Bulls and Sterility in Cows. Can. J. Comp. Med., 5: 267–268. 1941.

(31) MEIGS, E. B., AND CONVERSE, H. T. Some Effects of Different Kinds of Hay in the Ration on the Performance of Dairy Cows. J. Dairy Sci., 16: 317–328. 1933.

(32) MILLER, F. W., AND GRAVES, R. R. Reproduction and Health Records of the Beltsville Herd of the Bureau of Dairy Industry. USDA Tech. Bull. 321. 1932.

(33) MOEHL, E. Beobachtungen über die Folgen der Futternöl bei unsern Haustieren Wahrend de Kreigzeit. Vet. Med. Diss., Bern. 1922.

(34) MOORE, J. S. Feeding Sprouted Oats to Overcome Difficult Breeding. Miss. Agr. Expt. Sta. Ann. Rept., 40: 24. 1927.

(35) MOUSSU, R. Sur l'Avortement épizoötique des Bovidés Un Traitement Nouveau. Rec. de Med. Vet., 111: 905–919. 1935.

(36) NEWTON, O. R. Esterilidad de la Vaca par Adiposis de los Organos Genitales. Univ. Buenos Aires. J. Agron. Vet., pp. 433–444. 1939.

(37) PALMER, L. S., FITCH, C. P., GULLICKSON, T. W., AND BOYD, W. L. Supplementary Report of an Experiment to Determine the Effect of a Low Calcium Ration on Reproduction in Cattle. Cornell Vet., 25: 229–246. 1935.

(38) PALMER, L. S., GULLICKSON, T. W., BOYD, W. L., FITCH, C. P. AND NELSON, J. W. The Effect of Rations Deficient in Phosphorus and Protein on Ovulation, Estrus and Reproduction of Dairy Heifers. J. Dairy Sci., 24: 199–210. 1941.

(39) PHILLIPS, P. H., LARDY, H. A., BOYER, P. D., AND WERNER, G. M. The Relationship of Ascorbic Acid to Reproduction in the Cow. J. Dairy Sci. 24: 153–158. 1941.

(40) PHILLIPS, P. H., LARDY, H. A., HEIZER, E. E., AND RUPEL, I. W. Sperm Stimulation in the Bull Through the Subcutaneous Administration of Ascorbic Acid. J. Dairy Sci., 23: 873–878. 1940.

(41) QUINLAN, J. Researches into Sterility of Cows in South Africa. 15th Ann. Rept. Director of Vet. Services, Union of S. Africa, Pp. 833–1055. 1929.

(42) QUINLAN, J., ROUX, L. L., AND VAN ASWEGAN, W. G. Researches into Sterility of Cows in South Africa. Onderstepoort J. Vet. Sci., 12: 233–249. 1939.

(43) RICHTER, J. Die Sterilität des Rinds. Berlin. 1926.

(44) RIDDELL, W. H., HUGHES, J. S., AND FITCH, J. B. The Relation of Phosphorus Deficiency to the Utilization of Feed in Dairy Cattle. Kansas Agr. Expt. Sta. Tech. Bull. 36. 1934.

(45) RISSE, W. Behandlung der Unfruchtbarkeit mit standardisierten Weizenkeimöl (Vitamin E) und Hormovilan bei Rindern. Diss., Hannover. 1926. (Animal Breeding Abs., 7: 220–221. 1939).

(46) SCHEIDENHELM, E. C., BORTREE, A. L., HUFFMAN, C. F., AND CLARK, C. F. Some Preliminary Results of Feeding Chloretone to Bulls. J. Dairy Sci., 25: 690–691. 1942.

(47) SCHWEIZER, R. Ein Beitrag zur Sterilitätsbekämpfung. Schweiz. Arch. Tierheilk., 87: 374–378. 1945.

(48) SMIRNOV-UGRJUMOV, D. N., AND LAPTEV, M. A. The Feeding of Stud Bulls During the Mating Season. Problemy Zhivotnovod. 2: 64–72. 1938.

(49) SUTTON, T. S., KRAUSS, W. E., AND HANSARD, S. L. The Effect of Vitamin A Deficiency on the Young Male Bovine. J. Dairy Sci., 23: 574. 1940.

(50) THEILER, A., GREEN, H. H., AND DUTOIT, P. J. Studies in Mineral Metabolism III. Breeding of Cattle on Phosphorus Deficient Veld. J. Agr. Sci. 18: 369–371. 1918.

(51) TIMIN, K. S., AND PERETURINA, M. F. The Influence of Wheat Germ on Sperm Production of Bull Sires. Doklady Akad. Selzkohoz Nauk 6: 17–21. 1941. (Animal Breeding Abs., 11: 26. 1943).

(52) TIMIN, K. S., AND PERETURINA, M. F. The Effect of Wheat Embryos on Sperm Production in the Bull. Sovet. Zooteh., 5: 96–98. 1941. (Animal Breeding Abs., 11: 166. 1943).

(53) TUFF, P. Osteomalacia and its Occurrence in Norway. J. Comp. Path. and Therap., 36: 143–155. 1923.

(54) TUTT, J. F. D. The Treatment of Sterility in Cows with Wheat Germ Oil (Vitamin E). Vet. Record, 49: 568–569. 1937.

(55) VOGT-MULLER, P., AND BAY, F. On Treatment of Sterility in Cows with Wheat Germ Oil (Vitamin E). Vet. J., 87: 165–170. 1931.

(56) WALLIS, G. C. Some Effects of a Vitamin D Deficiency on Mature Dairy Cows. J. Dairy Sci., 21: 315–333. 1938.

(57) WEBSTER, W. M. Bovine Sterility in New Zealand. Australian Vet. J., 8: 199–223. 1932.

THE INHERITANCE OF FUNCTIONAL CAUSES OF REPRODUCTIVE INEFFICIENCY: A REVIEW[1, 2]

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That fertility is affected by the genotype of mates is borne out by observation, the opinion of popular writers in dairy cattle breeding and by research investigators. This has led to the need of paying attention to the reproductive efficiency of the family from which a prospective herd sire comes.

The great variation in the use of the terms fertility, infertility, sterility, reproductive efficiency, and others suggests the need for some delimitation of the different terms in the interest of clarity. Spielman and Jones (113) and Gregory *et al.* (37) considered the problem from its broad aspects and studied the integrated effect of all factors up to and including parturition, *i.e.* gametogenesis, estrous, ovulation, fertilization, implantation, gestation and parturition. Other workers, including Gowen (34) and Eckles (24), have used the number of services per conception as an indication of fertility. This criterion measures fertility at the earliest time possible for cattle. Unfortunately, no method is available for use with cattle to differentiate those not conceiving from failure of fertilization from those requiring extra services because of an early resorption or expulsion. From its strictest physiological sense, however, it would seem that fertility had been achieved once fertilization of the ovum by the sperm had taken place. Presumably, separate factors are involved in failure of fertilization as contrasted to the failure of subsequent processes involved in the successful completion of a gestation.

Evidence of a general nature that implicates genetic factors in fertility has been the differences found between breed groups, bull groups and cow families. Käb (62) studied the records of 7104 calvings and found that the daughters by 22 different bulls varied considerably as groups, thus indicating a genetic basis. High fertility was present in 35 groups and low fertility in 11 groups. Spielman and Jones (113) found a range in mean reproductive efficiency per cent in their breed samples of 65.55 ± 1.88 to 81.27 ± 1.67. Between cow families, the greatest range, *i.e.* 54.46 ± 4.83 to 87.23 ± 1.62 per cent, was found within the same breed. A correlation of $+0.546 \pm 0.118$ existed between the foundation cows and the mean of their respective descendants. Out of 20 cow families averaging 1.72 services per conception, Trimberger and Davis (120) reported one of extremely low fertility (2.92 s/c) and two with significantly higher fertility (1.00 and 1.22 s/c, respectively). When analyzed by bulls, the daughters of one sire required 2.25 s/c, which was significantly higher than the

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mean. These observations were borne out by Lagerlöf (70), Seath and Staples (105), and Taussig (118), who found a difference in the average calving interval between daughters of different bulls. Wagener (123) made similar observations in a Brown Swiss herd. Yapp (141) found reduced fertility in certain animals of the Illini Nellie family of Brown Swiss, and the classical example of the inherited suicidal tendency of the famous Duchess Shorthorn family also exemplifies the inherited phase of infertility.

The nature of the genetic effect upon infertility is not well known. In general, from studies in laboratory and some farm animals, a reduction in fertility is thought to accompany the reduction in body size sometimes associated with inbreeding. This could be due to the general action of genes for the lack of vigor or merely the absence of genes for vigor. This, no doubt, could be a factor in cattle. Another way in which the genotype of the animal could be important is in the presence of specific genes conditioning various types of infertility. That this is the case with cattle is supported by the work of Nielsen (91), who inbred Red Danish cattle and obtained no decrease in fertility along with a reduction of fat yield, size, thrift and conformation. Kobozieff *et al.* (65), in a review of the literature, stated that inheritance may be the cause of malformations of the genitalia and of endocrine disfunction, including sterility, intersexes and hermaphrodites. The inbreeding results on Holstein-Friesians from the Bureau of Dairy Industry (136) may be interpreted in the same light. One sire, more than all others, had a low conception rate in his daughters, most of which were highly inbred. The work of other investigators indicates more specifically that at least several types of infertility are conditioned by specific gene action. Certain genes adversely affect both cows and bulls. Others are sex limited in their effect. In females, because of the severity of the abnormalities caused, some are manifested at the time of breeding for the first pregnancy. In other cases where the affliction is less the manifestation may not be detected until a later age.

FEMALE INFERTILITY

White heifer disease. This type of inherited infertility gets its name from the fact that it often is observed in white Shorthorns and perhaps also because it presumably was the affliction of the famous "white heifer that travelled." The name is non-descriptive and, therefore, unfortunate. Spriggs (114) pointed out that no single lesion is descriptive, and the commonest characteristics in the order of frequency are: (a) closed hymen or hymen persisting in varying degrees; (b) distention of one or both uterine horns, the uterine body being present in rudimentary form; (c) complete absence of cervix and anterior vagina; (d) prominence of the Wolfian ducts; (e) presence of longitudinal submucous channels in the vagina; (f) aplasia of one uterine horn. Boyd (11) suggested this form of infertility is a deficiency in the development in which the Müllerian ducts are inhibited. The difficulty usually is detected when the afflicted heifer fails to conceive. However, Boyd detected one case at 2 months of age.

The difficulties involved usually are considered adequate to prevent conception. However, in England cases of this disease have been reported by Sprigg in which conception took place although the resulting parturitions were difficult. While the majority of cases have been reported in white Shorthorns, cases have been reported in roan Shorthorns by Hart (42) and Tutt (121), red Shorthorns and Angus by Hart, Holstein-Friesians by Fincher and Williams (31), and Sellers (107), and possibly in the buffalo (93). Since in Shorthorns the number of reds and roans greatly outnumber the whites, it has been considered significant by Hutt (54) that this disease is associated most frequently with white Shorthorns. Hence, it has been concluded that linkage with a low percentage of crossing over occurs between the gene for white (N) and the recessive gene for this type of infertility. Its infrequent presence in other Shorthorns and in other breeds is accounted for by crossing over between the two genes on one of the autosomes. Because only females are involved, this is a case of sex-limited inheritance.

Freemartin. While the cause of this infertility undoubtedly is chemical through a humoral agent (85), it should be noted here. The primary cause is the occurrence of bisexed twinning which is fraternal or dizygotic and has an inherited basis. The weight of evidence indicating an inherited basis for multiovular births of the order of twins and higher comes from studies of the repetition of multiple birth with the same cow by several workers, including Pearl (94), Hayden (43), Hutt (51) and Palalumbo (92), the difference in their incidence between herds, sire groups and cow families by Johansson (58) and between breeds by a large number of workers including Jewell (57), White *et al.* (127), Lush (79), Knott (64), Johansson (58), Koch (66), Ward, (124), Bonnier (10), and Pfau *et al.* (95). The exact nature of the inheritance is unknown. Holze (46), however, claimed that twinning is due to the action of a sex-linked gene with dominant effect. Freemartins occur in approximately 91 per cent of all bisexed twins and represent those developed in the same placental membranes. The abnormal development consists essentially of an underdevelopment of the Müllerian ducts and an over development (for a female) of the parts arising from the Wolfian ducts. The degree of maldevelopment varies tremendously from no observable external freemartin characteristics to cases showing the presence of a penis extruding from the position normally occupied by the vulva. Undescended testes were palpable above the udder.

The early identification of freemartins consists of detecting a possibly abnormally large clitoris (117), underdeveloped mammary gland, a fold of skin extending from rear udder attachment to navel, and the use of an ordinary test tube to detect the size of the vagina (29). Whereas a normal heifer will offer slight resistence to the passage of this tube, in a freemartin the tube can be inserted only 3 to 3.5 inches before contacting the end of the urinogenital sinus.

Adolescent infertility. Adolescence has been considered by some (4) to be that period beginning with the first estrous and extending to the time conception is possible. This time of functional infertility has been observed in some

other forms, and if it exists in cattle it explains some of the cases of temporary sterility commonly observed. That such cases exist is supported by the observations made by Winters *et al.* (134). From matings made with heifers in their first or second estrous periods for embryological studies, a relatively large proportion of apparently abnormal ova were recovered.

The existence of this form of infertility is suggested also by the classification of the three stages of sexual development in cows by Wille (128) as follows: (a) Maturation of the hypophysis (3–6 mo.). (b) Maturation of the ovaries (6–12 mo.). In north German breeds he found a regular estrous first established between 12–15 mo. (c) Maturation of the uterus. Full maturity is not reached until completion of skeletal growth towards the end of the third year. Therefore, it was considered that abortion during the first pregnancy may occur if the cow is bred too early. Furthermore, the greater number of services per conception for cows bred for their first pregnancy in some breeds (87, 45) but not in others (6, 20) might be taken to indicate the operation of inherited factors causing adolescent infertility. No mode of inheritance is known.

Ovarian hypoplasia (*underdevelopment*). Gonadal hypoplasia may occur in both sexes and was found by Lagerlöf (71) and Eriksson (28) in clinical examinations of 178 herds of Swedish Mountain cattle containing approximately 6000 cattle. The proportion of left sided, right sided and double sided hypoplasia in females was 82.3, 3.3 and 14.4 per cent, respectively. In bilateral hypoplasia in the female, the whole tract is underdeveloped and the animal does not come into heat, thereby being completely infertile. The follicles were more or less underdeveloped.

Most animals of the breed trace back to two bulls, according to Eriksson, one of which is thought to have carried the gene for hypoplasia. Owing to the wide use of hypoplastic bulls, the frequency of the gene for this affliction rose to 25.6 per cent in 1935. An official slaughter program, started in 1937, reduced the frequency to 7.9 per cent in 1942. The incidence of the gene during the same period was reduced from about 0.72 to 0.40 per cent. The gene involved is believed to be an autosomal recessive with a penetrance of 0.5654 in females.

Gonadless. Some heifers are found with a virtual absence of ovaries. The ovarian tissue that was present (19–25 mo. age), possibly on only one side, resembled the ovary of a bitch. Other characteristics are the small uterus, cervix and vagina of an infantile genital tract but slightly larger than it was at birth. To all external appearances, the heifers observed were normal until breeding age was reached, at which time no heat periods were evident. Normal udder development was lacking because of the absence of the follicular and corpus luteum hormones needed for its growth. This condition was observed in New York by Fincher (29) in three daughters of one cow, each daughter being sired by a different bull. The cow had two normal daughters. One was a twin and one a full sister of two of the gonadless daughters. The cow, herself, was a double granddaughter of a famous brood cow. In the absence of additional cases, this condition appears to be inherited as an autosomal dominant.

Incompletely developed uterine horns. The typical effect in this abnormality, according to Fincher and Williams (31), is the failure of the Müllerian ducts to develop into uterine horns. The common results, therefore, were uterus unicornis, atresia of one or both horns at the base, uterus didelphis (double uterus resulting from the arrested fusion of Müllerian bodies in caudal segments resulting in two distinct uteri), a persistence of the medial walls of the Müllerian ducts at the os uteri externum (two cervices), and a fibrous band over the cervix. Fincher and Williams (31) reported complete infertility in 56.5 per cent and virtual infertility in an additional 13 per cent of the inbred daughters of a Holstein-Friesian bull produced from his own daughters. Seven inbred sons were sold as breeders with one being returned as a non-breeder. It is assumed that the male infertility was due to a different cause and ascribable to malformed Müllerian elements which are rudimentary in the bull. Therefore, it is thought, that sex limited inheritance is involved. This appears to be a case of a single recessive autosomal gene of a sex limited nature.

Female infertility. (*a. Jersey and b. Holstein*). Regarding as fertile any cow that gave birth to a calf following a normal gestation, the workers at the

TABLE 1

The relation of infertility with inbreeding (80)

Degree of inbreeding	Fertile	Infertile	Unclassed	Incidence of infertility	Gene frequency
Jersey					
f = 0.03125–0.469	149	12	4	7.41	}
f = 0.–0.03124	94	3	4	3.09	} 0.333
Holstein-Friesian					
f = 0.03125–0.469	67	4	1	5.63	}
f = 0.–0.3124	21	1	0	4.54	} 0.083

California station (37, 80) studied the incidence of infertility from a qualitative standpoint. Any female, free from infectious diseases was considered infertile if she failed to produce a calf after repeated services to one or more fertile bulls. No trichomoniasis existed in the herd. The infertile females were examined by a veterinarian who classified the reproductive organs as normal or abnormal. The infertility found in Jerseys was found in females that manifested normal heat, indicating normal ovarian development as in the above cases described by Fincher and Williams (31) in Holstein-Friesians. The cases of infertility found in the California Holstein-Friesians show abnormal estrous cycles and usually complete absence of heat. Thus, the latter type is differentiated from the infertility found in the Jerseys of California and the incompletely developed uterus. Two hundred sixty-six Jersey females by 16 different bulls were classified as to fertility. Those that were inbred had an incidence of infertility twice as great as those that were non-inbred (table 1). The 94 Holstein females by two different bulls classified showed an incidence of 5.63 per cent infertility among the inbred groups as compared to 4.54 per cent among the outcrossed group.

It is concluded that each of these types of infertility is due to a separate autosomal recessive gene and that the manifestation of the character is limited to the female sex.

Tubular genitalia. In a study on reproductive efficiency at the Kentucky Agricultural Experiment Station herd, Hull *et al.* (49) found a condition of tubular genitalia to prevail in the inbred daughters of one Jersey bull. The vulva and cervix were especially constricted, resulting in difficult parturition following the first pregnancy. Surgery was resorted to in seven of the nineteen daughters calving. While this appears to be a character conditioned by inheritance that affects fertility when considered in its broadest sense, the mode of inheritance is not known.

Adiposity surrounding genitals. Newton (89) has reported that fat in the cows of quick fattening breeds such as Shorthorn, Hereford and Angus may cause infertility if it extends to the genital organs. Fatty deposits in the bursa prevent the ovary and fallopian tubes from maintaining close apposition, thus preventing ova from entering the fallopian tube. The condition can be determined by rectal palpation. Its importance impinges on dairy cows, because it sometimes is present in cows which show no outward signs of excessive fat.

MALE INFERTILITY

Various types of inherited infertility in the male have been reported. They include hypoplasia of the testis, impotentia coeundi, umbilical hernia, intersex and three different types of abnormal spermatogenesis.

Testicular hypoplasia. Normal spermatogenesis does not occur because of the underdeveloped epithelium in the seminal ducts. In cases of bilateral hypoplasia, sperm formation is absent, but the sexual desire is normal or above average. A laboratory examination of Swedish Mountain bulls by Lagerlöf (71) showed varying degrees of retardation. The clinical examinations made showed the proportion of left, right and double sided involvements to be 81.9, 3.6 and 14.6 per cent, respectively. The difference found between males and females was not significant. The evidence for this affliction being inherited was established by Eriksson (28). Impotent bulls sired a larger percentage of impotent offspring than did normal bulls. By eliminating hypoplastic bulls, slaughtering some hypoplastic cows and selecting as herd bulls those not showing hypoplasia the disturbance was reduced from 16 per cent in 1937 to 7.9 per cent in 1942. Teunissen (119) found watery semen with an abnormal sperm count. This condition is caused by the same autosomal recessive gene that causes ovarian hypoplasia, the possible difference being of a sex limiting nature. In males, the penetrance is 0.43 as compared to 0.57 in females. The presence of hypoplasia also has been reported in cattle in the U. S. by Fincher *et al.* (30).

Impotentia Coeundi. The inability to copulate in the male was found by de Groot and Numans (19) to be caused by the failure of the sigmoid curve of the penis to straighten during erection. This S-shaped curve is located behind the scrotum (110). Its formation folds back about a foot of the penis in the

retracted state. The retractor penis muscles are continuations of the suspensory ligament of the anus. They come close together and pass on either side of the penis at the ventral curve of the flexure and end 5 to 6 inches posterior to the glans.

This anomaly has been treated surgically in Holland where seven cases had been observed by 1937. Although the cure is complete, it results in disseminating the causative genes. The number of cases increased to 24 by 1941, and it was found that 22 cases with complete pedigrees included one or both of two bulls with all but one case having a normal sire. The condition is thought by de Groot and Numans (19) to be caused by an autosomal recessive gene.

Umbilical hernia. In the male an umbilical hernia may become a physical interference with the act of service, according to Williams (131), who indicated that this character definitely is associated with breeding efficiency. That umbilical hernia is inherited was suggested by Murray (88) and is indicated by the data of Warren and Atkeson (125) who observed 21 cases in males with a common ancestor in three Idaho herds of Holstein-Friesian cattle. The case of one herniated female was thought to arise from non-hereditary causes. The mode of inheritance, while not definite, appeared to be that of a sex-limited dominent gene. In the Holstein-Friesian herd at the Minnesota Agricultural Experiment Station, five cases of umbilical hernia were observed by Gilmore (32) involving two males and three females, one of which was a freemartin. The condition appeared during the first month and persisted up to slaughter (at 8 months in one male) and was present in the females at 18 months. The five cases were sired by two unrelated bulls, but close relationship existed among the dams and grandams. If a dominant gene was responsible, the penetrance was low.

Intersex. Six Brown Swiss bulls with normally developed secondary sexual characteristics were found by Yapp (140, 141) to be infertile. A histological examination of one showed the absence of functional testicles (one present in rudimentary form) and accompanying ducts. A normal female reproductive system, except for a portion of the vagina and vulva, was found. Three of the cases were by one bull, two of the three cases being full brothers.

Returned tails. This terminology was used by Blake (8) to describe sperm that are abnormal with respect to their tails being turned back past the head. A marked degree of closeness was found between the observed sperm morphology and that predicted from pedigrees showing inbreeding to a bull, *Z*. Bulls having *Z* close up in their pedigrees on both sides were eight times as likely to have returned tails as bulls not connected with *Z* for several generations back. That morphological characteristics of the sperm are affected by the bulls genotype is evidenced further by the New Zealand work in which it was found possible to distinguish smears made with semen from Jersey bulls as compared to Friesian or Shorthorn bulls. The criterion was the wider sperm head of the Friesian and Shorthorns as contrasted to the Jerseys.

Semen quality. Deakin (17) encountered a few bulls with apparently nor-

mal semen that had poor keeping qualities. Because ejaculates with high sperm counts tend to store better, it was suggested that there is a variation in the degree of toxicity of accessory gland secretions between bulls, and that selection of bulls for artificial insemination from strains producing semen high in sperm and "neutral" accessory gland secretions might be helpful.

Failure of spermatogenesis. That the scrotum functions as a thermo-regulator has been known for some time. The temperature within the testicles as measured by Riemerschmid and Quinlan (101) remained within the narrow range of 34.7 to 37.8° C. In certain intersubgeneric crosses, the failure of males to undergo spermatogenesis has been considered to be due to excessive temperature within the seminiferous tubules. The inheritance seems to be that for the large testicle of the European (Taurus typicus) and the small scrotal sac from the other parent. Crosses in which this type of infertility has appeared are bison × domestic cattle (18), yak × domestic cattle (96) and yak × zebu (142).

LETHALS

In addition to the above described inherited effects on fertility itself, i.e. conception, genes affecting the viability of the fetus prior to birth or of the organism after birth are important in the over-all reproductive efficiency. The characters reviewed here are those that are associated with premature death under conditions of ordinary environment. No attempt has been made to separate sub-lethal and semi-lethal characters.

Evidence for the existence of 26 gene-causing lethals is reviewed. The tissues primarily affected are cartilage and bone, muscle, epithelium and nerve. Fifteen come under the first class in which an attempt has been made to arrange them according to the similarities of the malformation. This is done to encourage workers to report other pertinent cases that will lead to a sharper line of delineation or to an elimination of some duplicating terms, as the case may be. An attempt is made to arrange them according to the tissue primarily affected.

Several excellent reviews and check lists are available. In the order of their publication they are those by Hutt (52), Schäper (104), Eaton (23), Lerner (74) and Shrode and Lush (109).

Achondroplasia. The bull-dog calves of the Dexter breed in Ireland and England were described by Seligman in 1904 (106), who credited German investigators with having described similar calves as early as 1860. Not then known to be hereditary, the condition was observed to be extremely marked and constant. Affected calves were described as having short vertebral columns, inguinal hernia, thick and loose skin, head with extreme brachycephaly, rounded forehead bulging over a greatly depressed nose with projected mandible, long swollen tongues, cleft palate and legs about half normal in length. An abnormal thyroid, with increased vascularity and colloid commonly absent, also was described. This thyroid upset first led to the diagnosis of this disease as a cretin. The 21 cases out of 82 births (25.6 per cent) in two herds usually were aborted

after death in the sixth to eighth month of pregnancy following a pronounced accumulation of fluid in the dam by the fourth or fifth month. Wilson (132) described the fate of the Dexter breed after establishment of separate herd books for both Dexter and Kerry cattle in 1890. He reported that 25 to 50 per cent of the offspring of Dexter parents were malformed.

A black and white calf with similar symptoms was diagnosed in Minnesota by Nickerson in 1917 (90). Attention was directed to the similarity of congenital achondroplasia in humans, and the condition in cattle accordingly was so classed. Crew (15, 16) found a definitely smaller hypophysis in the compressed surroundings and concluded that the condition was due to malfunction of the hypophysis between the second and third month of pregnancy. He, accordingly, ascribed the abnormal thyroid condition to hypofunction of the anterior pituitary. It was further concluded by him that the associated anasarca, hydrocephalus and hydramnios could be caused by a posterior lobe deficiency which he found. In discussing this work, Pugh pointed out that the bull-dog calf is a non-viable form of achondroplasia, while the pug-dog and Dachshund were viable forms in which the head and limbs, respectively, were singly achondroplastic without malformation of other parts. Crew used the term, achondroplasia, as a group name to include such anomalies as micromelia, chondritis fetalis, osteogenesis imperfecta, pseudo-chondritis, cretinoid dysplasia, micromelia chondromalacia, osteoporosis, periosteal aplasia and chondrodystrophia fetalis. Crew cited the suggested term of Kaufmann (1893), chondrodystrophy fetalis, as being more descriptive than achondroplasia, of the Dexter bull-dog condition of arrested bone formation in existing cartilage. Mörch (86) pointed out that achondroplasia (chondrodystrophia fetalis) in humans always is inherited, always dominant and is produced rather frequently by mutation. A similar condition occurs in the creeper fowl (Landauer and Dunn, 73), where the lethal period has been shown to begin with the fourth day of incubation.

Against the above historical background, four types of achondroplasia will be reviewed.

Achondroplasia 1 (*chondrodystrophia fetalis*). That Dexter cattle (brachydephalic and micromelic) are heterozygous for the incompletely dominant gene causing this condition and, therefore, segregate in a 1:2:1 ratio was suggested by Hutt (52). The homozygous dominant one-fourth of the population are bull-dog, one-half are heterozygous and therefore Dexters, while the recessive one-fourth are normal-legged Kerry cattle. The causative gene in cattle, as in humans, appears to mutate frequently from the normal. The same abnormality has been described in Zux-Tillertal of Austria by Adametz (1), in a white-faced calf with solid body in Michigan by Downs (22) and in Jerseys in California (81). Four cases in British Friesians, reported by Berger and Innes (7), were concluded to be of this form.

Achondroplasia 2. Wriedt (137) described a condition in the Telemark cattle of Norway similar to the bulldog calf. However, it was more compatible with life, as affected calves usually are born alive after a gestation of normal

length. With the exception of one that lived 3 months, they die within a few days because of a respiratory obstruction causing asphyxiation. The recessive gene responsible was found also in grade Jerseys by Brandt (12) and Surrarrer (116) and in Guerneys by Brandt and by Winters (133) and in Ayrshires by Brandt. Weinkopff (126) described a case in German Friesians. The 12 cases described by Carmichael (13) probably should be classed here rather than as the dominant type (achondroplasia 1) on the strength of the statements that the Nganda cattle breed true (therefore, not heterozygous), and that one affected calf lived a few hours. Apparently, it was carried full term.

In one of the few cases in cattle where phenotypically similar characters are involved, critical matings were made by T. H. Riches and reported by Punnet (97), to find out if these two types of achondroplasia are caused by the same or different genes. A heterozygous Telemark bull was mated to eight Dexter cows with a resulting 24 normal calves and one mummy being produced. The normal calves were about equally divided between those with normal legs and those with Dexter-type legs. The conclusion that the characters in the two breeds were caused by two separate single autosomal genes was confirmed by segregation in the F_2 progeny which included one Telemark and three Dexter monsters.

Achondroplasia 3. This form of achondroplasia was described in California Jerseys by Gregory *et al.* (35). It is recessive but more variable in its expression than the Telemark type and the gene involved has little, if any, effect on leg length. A lower grade achondroplasia than types 1 and 2 seems to be involved. Although they may die shortly after birth, one animal lived to be slaughtered at 14 months. In common with other types of achondroplasia, the affected calves can be distinguished at birth. The head is short with a wide cranial vault. The maxilla sometimes is shortened and the palate commonly is cleft.

Achondroplasia 4 (*Micromelia*). This appears to be a lower type (higher viability) than that found by the California workers, with short legs and shortened mandible the distinguishing characteristics. The existence of this particular dwarfness is based on the appearance of three affected calves in the Jaroslav breed in Russia described by Ljutikov (78). They all descended from a high producing cow found in a peasant's herd. No physical defects were noted in any of her offspring, and because of her high production a program of inbreeding to her was developed. The three cases noted resulted from different descendants of this brood cow being mated, respectively, to a son, a grandson and a half-brother of this cow presumably, Zolataja (76). All cases had short legs. The lower jaws were shortened to different degrees. In the case of a twin bull calf, the disproportion of jaw length was so great that, although it could drink, the calf could not eat grass and hay. Accordingly, death followed from a secondary cause of failure to get along in the normal environment of cattle. In the other two cases, the shortening of the lower jaws was not enough to prevent them from eating any feed eaten by normal cattle.

When compared to his normal twin-brother, the most severely afflicted calf (Zolataja × grandson) had a ratio, $\frac{\text{body length}}{\text{distance from knee to ground}}$, that was 1.4 times the normal ratio. A plan to breed the sire of the twin bulls back to his daughters did not materialize. One breeding bull, Golden May, heterozygous for micromelia, sired 14 sons that were valuable for their production inheritance and, thus, could be the source of widespread dissemination of this gene. This is another case where the presence of a lethal gene along with genes for high production can mean its widespread dissemination, sometimes before it is detected. Micromelia has been described in chickens by Asmundson (5).

Amputated (*acroteriasis congenita*). The rear legs may be absent from hock or may be normal. The pelvis is normal. The forelimbs end with the arm or humerus. The elbow and fore arm are absent. The humerus and scapula (shoulder blade) are ossified to form a right angle. The upper jaw is underdeveloped and the lower jaw is almost completely absent giving a "parrot bill" appearance. Affected calves show hydrocephalus. The palate is cleft. The ears are short and unsymmetrical. The affected calves are usually dead at birth or they die shortly after birth. This condition is due to a recessive gene and has been found in Swedish Friesians by Wriedt and Mohr (139). Out of 115 offspring sired by heterozygous bulls and out of daughters by heterozygous bulls, 102 were normal and 13 were affected. This ratio is in close agreement to the expected 7 : 1 ratio of a character affected by a single recessive gene. A similar lethal has been reported in swine (61) and a less severe one in sheep (74).

General ankylosis. The malformation of true or bony ankylosis is the abnormal union of the bones of a joint (21). The fore legs mainly are affected. These conditions have been described for Friesians in Russia by Ruzhevsky (103), in Germany by Stang (115) and in Jerseys in the United States by Spielman *et al.* (112). The descriptions of "flexed limbs" in Gir and Indo-Brazilian zebu cattle by Veiga (122) and of "curvature of the fore limbs" by Remmers (100) are of similar or identical character. If the same gene were involved in all cases, the expression is variable and may include muscular contracture, cleft palate, flexed spine, wry neck and internal abnormalities. Affected animals are dead at birth. The large number of cases described have resulted from inbreeding programs and, therefore, the appearance of a recessive gene involvement is given.

Because of the observations both of Williams (129, 130) and Spielman *et al.* (112) that symptoms of "muscular" contracture were found in cases of ankylosis, the question is raised here as to whether or not these two characteristics are different manifestations of the same genes.

Ankylosis of lower jaw. The lower jaw is ossified at its joint (region of the condyle and coronoid process of the mandible and the zygomatic process of the temporal bone). A shortening of the jaw also is found. This is caused by a recessive gene found in the Lyngdal breed of Norway by Mohr (82).

Agnathia. This imperfect development or absence of the lower jaw was

found in one Aberdeen Angus calf, and in four Jersey males by Ely *et al.* (27). The mandible of one case carried full term consisted of osseous, soft and tooth-forming tissue so reduced in amount as to give the appearance of a jawless calf. The temporomandibular joints were ossified completely. A slight hydrocephalus was found. Wattle-like appendages 0.5×0.25 cm. were found located on the side of the head. Abortion may occur as early as 75 days. A recessive gene coming from two related herd sires is indicated. A somewhat different case without wattles was described by Lalonde (72) in Quebec cattle, but nothing was reported on its inheritance.

Impacted molars. This defect also has been called "parrot beak" by Snyder (111) because of the undershot or shortened lower jaw that results in a mouth with a flattened appearance. However, a similar term, "parrot bill" was used to describe an amputated calf and the term "parrot jaw" is listed as a defect with "slight to serious discrimination" on the score card of The Purebred Dairy Cattle Association (1943) as approved by the American Dairy Science Association. Accordingly, in judging dairy cattle, the term refers to an undershot lower jaw which is not lethal.

Impacted molars, as first described by Heizer and Hervey (44) and later by Annett (3), consists of an impaction of the premolar teeth in the mandible. The interalveolar spaces are greater than normal. Both sides are affected similarly. The normal incisor teeth are normal. The jaws are normal except for a fracture on the left side apparently caused by the force of the impaction, a feature which apparently is characteristic. Affected calves are born alive but die during the first week.

Both males and females are affected. The appearance of this character has been observed in over 100 Milking Shorthorns in Ohio and New Zealand. It has been concluded by Ranstead (98) that all affected animals trace back to the same carrier. The condition of impacted molars is caused by a single recessive gene located on an autosome, with complete dominance of its allele

Hydrocephalus. The condition described in cattle by Cole and Moore (14) is internal hydrocephalus in which the fluid is found in the cerebral ventricles upon autopsy. Contrasted to this type is external hydrocephalus, as found in swine (9), rats (47) and mice (38), in which the excess fluid is found outside the brain tissue. Internal hydrocephalus in cattle is accompanied by marked swelling and great enlargement of the ventricles of the cerebrum. The pressure developed was great enough to cause an enlargement of the cranial vault two to three times the normal size. Other abnormalities found in these calves were shortened humerus and femur bones and joints giving the appearance that pressure had been applied from the ends. The twisted femurs caused a wide pelvis that made parturition difficult. The abnormal humerus gave a twisted appearance to the fore legs. Associated with this lethal were conditions for "asymmetry" (wry face) and "jumpy" (muscular incoordination). The limited data indicated that the three characters had independent inheritance, unlikely as is the chance for the presence of these three genes in one animal. The lethal, *hydro-*

cephalus, appears to be inherited as a single recessive and was found in a herd of Holstein-Friesians in Michigan where a bull was bred back to 15 daughters. A case of non-lethal hydrocephalus in the United States sired by a "Durham" bull out of a Jersey × Herford cow was reported by Houck (47).

Cerebral hernia. Two affected Holstein-Friesian calves were found by Shaw (108) to have an opening in the skull involving a failure of complete ossification of the frontal bones with a possible involvement of the parietal bone. The opening thus resulting, with the absence of the meninges, permits the brain to protrude, causing a hernia. Such calves may be stillborn or die shortly after birth. A similar condition has been reported in humans (Catlin Mark) (33), swine (48) and mice (63), where it is inherited as a recessive.

Short spine. The vertebral column is shortened to about half the normal number of 13 ribs and corresponding thoracic vertebrae. The remaining vertebrae and ribs are fused. Calves are either stillborn or die shortly after birth due to suffocation during difficult birth with breach presentation. One case lived 4 days. The gene responsible is inherited as a recessive and was found in the Oplandske breed of Norwegian mountain cattle by Mohr and Wriedt (84).

Missing phalanges. The missing bones in this condition, described by Johansson (59, 60) in Swedish cattle, were the first and second phalanges (pastern and coronary region, respectively). As a result, the hoof connects to metacarpal and metatarsal bones only by tendons and skin. The metacarpal and metatarsal bones were shortened considerably. Accordingly, the calf cannot stand but crawls on carpal joints and the hocks. Calves are born full-term and are otherwise normal. A recessive gene is thought to be responsible.

Mummification. This causes a shortened neck, stiffened legs and prominent joints. It is thought to be associated with muscle contracture and fetal resorption. The latter may be due to a separate gene. The majority of the mummified fetuses are aborted during the eighth month of gestation. Some that apparently died during the eighth month were carried full term. This recessive lethal was found in Danish Red cattle by Löje (cited by Lerner 74).

Lameness. The affected Danish Red calves found by Nielsen (91) were lame in the rear legs and could not stand, probably because of an affliction of the tendon and ligaments. All cases show the same symptoms. The affliction permits the calves to be born alive, but they only live 2–3 weeks under normal environment. The segregation of 294 affected calves by 39 bulls, from 213 cows, including 36 cows with two lame calves each, did not agree with single factor inheritance, although all cases were traced to a single ancestor through both sire and dam. The maldevelopment was concluded to be caused by two complimentary genes.

Muscle contracture. There is extreme rigidity of the neck and all limbs. The head is bent back. The fore and rear legs are drawn together toward the body. Parturition, accordingly, is difficult and in some instances assistance is rendered by dismembering the fetus. Calves are carried full term and die during birth or shortly afterward. The dams also may be permanently injured

or rendered sterile. This lethal is caused by a recessive gene. It has been found in Norwegian and Danish Red cattle by Mohr (82). In the United States, five cases have been described in Holstein-Friesian herds of Northern Minnesota by Hutt (53). Muscle contracture also has been reported in sheep (102) and in swine (41). The suggested relationship between this character and ankylosis is given under the description of the latter character.

Epitheliogenesis imperfecta neonatorum bovis. This lethal reported by Hadley (39) and Hadley and Cole (40) is a case of imperfect development of skin with death the primary result of septicemia which results from infecting bacteria gaining entrance through the raw surfaces of the lesions. Characteristics of the abnormality are defective formation of skin below the knees and hocks, underdeveloped claws, ears deformed by rolling of the margins and growing together and denuded muzzle and mucous membrane of the nostrils, tongue, hard palate and cheeks. Affected calves are carried to full term and are normal in size. The nature of the ear defect indicated the lesions antedated birth by several weeks. Fifty-five defective calves found in 18 herds all traced back to common Holstein-Friesian stock and experimental matings indicated its inheritance to be a single recessive. The same condition has been found by Kroon and Van Der Plank (68) in Holland Friesians herds that had contained the ancestors of the Wisconsin defectives. It was reported in Montana Brown Swiss and possibly Wisconsin Shorthorns (39), and in Jerseys by Regan *et al.* (99) and Wipprecht *et al.* (135), both of whom described the condition independently from cattle of common descent (26). Hutt and Frost (55) also have found a condition in Ayrshires resembling that of the Friesians more closely than the Jersey. These authors suggested that the breed difference found by comparing the characteristics of the abnormality in Friesians and Jerseys with Ayrshires (and the Shorthorns) may be due to different genes or to an effect on the mutant gene by the genotype in which it operates.

Fused nostrils (*Abnormal skull*). This lethal, causing the nasal passages to be fused, was found in the mountain breed of Croatia by Ilancic (56). The calves die at birth or shortly afterward because of respiratory difficulty. The skull was depressed abnormally between the eyes. This condition was thought by Krallinger (67) to be caused by a dominant lethal gene that is inhibited by a homozygous recessive gene. Thus, a bull heterozygous for the lethal and recessive for the inhibitor mated to cows recessive for the lethal and homozygous dominant for the inhibitor would produce approximately half abnormal calves. This conclusion of Krallinger is based on the results of Ilancic in which a bull sired 37 abnormal and 33 normal calves which is almost a 1 : 1 ratio.

Atresi ani. Calves with an imperforate anus are born alive and may live for several days. They do not survive surgery. Both affected males and females have been found in cattle of the Ganjam district in India by Kuppuswami (69). One hundred and five cases have been reported. A case has been observed in Minnesota Holstein-Friesians by the reviewer, but in this instance it was not established as being inherited. Similar lethals are found in swine (74).

Hypotrichosis congenita (hairless). Such calves have no hair on the body except on the muzzle, eyelids, ears, pasterns, switch, umbilicus and external genitalia. Fuzz instead of normal hair is present on the rest of the body. The hair follicles, normal in number, are under-developed and, accordingly, at birth the calf has an appearance similar to that of early embryonic development. The sweat glands, however, are over-developed in affected areas. Calves are born alive but usually die a few minutes after birth. In two reports calves lived for several months. It is caused by a recessive gene. It was found in Swedish Friesians by Mohr and Wriedt (83) and Johansson (59) and in German Friesians by Eisele (25). In the United States it was found in "Durhams" by Surrarrer (116).

Congenital spasms. Affected calves are born alive and live for a few weeks. They have intermittent spasmodic movements of head and neck, usually in a vertical plane. When forced to stand they exhibit spasms in both fore and rear legs which hampers either standing or walking. Spasms are neither initiated nor intensified by noise or shock. While they live, they appear vigorous and have good appetites. It is inherited as a recessive and was traced through 10 generations of grade Jerseys by Gregory *et al.* (36).

Congenital dropsy. This abnormality was found in Swedish Lowland cattle by Johansson (59) who quotes the earlier work of Larsson. The wide range in variation of characteristics includes the accumulation of water in the subcutaneous tissues and in the thorax and abdomen. There also is much fluid in the head and neck. Affected calves are carried from 5 months to full term with a pronounced dystocia when the gestation exceeds 200 days. When carried full term they are born alive. An affected fetus may weigh two and one half times the normal. A recessive gene is involved.

Ljutikow's lethal. This lethal was named after its discoverer (75), and results either in abortion, stillbirth or in death shortly after birth. No specific cause of death was ascribed, and no gross abnormalities were noted. It was found in 14 per cent (200) of the 1423 calves studied in the Swiss, Friesian, Allgauer and Shorthorn herds located at the Alma-Alta, Kinel, Pogrom and Timiriazeo Station of the U.S.S.R. This corresponds to a 7:1 ratio expected of a recessive gene segregation where the mating of heterozygous sires to their daughters was practiced.

From the same group of herds, a total of six monsters appeared. Contrary to some reviews, no evidence for an inherited cause was established. At least three of the monsters were characterized by having short legs with underdeveloped hoofs. The affected hoofs were from a front and a diagonal rear leg. The hoof either was not cloven or only mildly so.

Sex-linked lethal 1. Andreesen (2) rests his case in Angeln cattle on a low sex ratio. The progeny of 77 female lives gave 5302 males and 6594 females. This ratio of 44.57 per cent was considered a significant deviation from the expected to establish a lethal condition occuring in the male fetus. The calving interval also was longer for females assumed to carry the gene.

Sex-linked lethal 2. Evidence for the existence of a lethal causing a statistically significant greater loss in males than females was found in the Minnesota Agricultural Experiment Station Holstein-Friesian herd by Hunsaker and Gilmore (50). Three times as many males as females were dead at birth or died within a few days after birth. The differential loss was associated with cow families and with sire lines. The validity of the comparison was enhanced by comparing offspring of a three-generation sire line thought not to carry the responsible gene, with offspring of members of two other sire lines assumed to carry the gene for the lethal character. The sires in the first line were used more or less alternately with bulls of the other two lines. The mode of sex linked or sex limited inheritance is not yet clear. A recessive gene is suspected because of the inbreeding practised. This lethal is assumed to be different from the one reported by Andreesen (2).

Sex-linked lethal 3. In a Russian Swiss herd, Ljutikow (77) found a preponderance of males in some sire lines. With a total sex-ratio of 53.7 per cent males, the offspring of six bulls (including a sire, two sons and a grandson) gave a ratio of 61.5 per cent as compared to 50.4 per cent for the get by eight other herd bulls. This preponderance of males is explained by the presence of an autosomal gene lethal in heterozygous form in female and non lethal in the male (a dominant inhibitor on the Y-chromosome). It was postulated further that YA sperm are less viable than XA sperm.

The most generally recognized long-time effective treatment is the elimination from breeding stock of the genes responsible for undesirable characters. The general distribution of undesirable genes by otherwise great sires is well illustrated by Wriedt (138), who pointed out the economic disadvantage of using bulls carrying lethal-producing genes. The importance of testing bulls suspected of carrying undesirable genes is indicated.

REFERENCES

(1) Adametz, L. Neues über den disproportiomerten Zwergwuchs (Achondroplasie) als Rassen bildende Domestikationsmutation. Zeit. f. Züchtung, 3: 125–140. 1925.

(2) Andreesen, A. Untersuchungen des zahlenmässigen Geschlechtsverhältnisses beim Angler-Rind und Prüfung des Vorliegens eines rezessiven geschlechtsgebundenen (antimaskulinen) Letalfaktors. Diss. Hanover, 1940. (abs., Deut. tierärztl. Wochschr., 49: 77. 1941.)

(3) Annett, H. E. Note on a New Recessive Lethal in Cattle. J. Genetics, 37: 301–302. 1939.

(4) Ashley-Montagu, M. F. Adolescent Sterility. Quart. Rev. Biol., 14: 13–34, 192–219. 1939.

(5) Asmundson, V. S. An Inherited Micromelia in the Domestic Fowl. J. Heredity, 33: 328–330. 1942.

(6) Berge, S. Fertility and "Pregnancy Percentage." (translated title.) Nord. Jordbrugsforskning, 214–224. 1942. (Abs. J. Dairy Sci., 29: A143–144. 1946.)

(7) Berger, J., and Innes, J. R. M. "Bull-dog" Calves (chondrodystrophy, achondroplasia) in a Friesian Herd. Vet. Record, 60: 57–58. 1948.

(8) Blake, T. A. Inheritance of Morphological Characters in the Sperm of Cattle. Nature, 155: 631. 1945.

(9) BLUNN, C. T., AND HUGHES, E. H. Hydrocephalus in Swine. J. Heredity, 29: 304–308. 1938.
(10) BONNIER, G. Studies on Monozygous Cattle Twins. Acta Agr. Suecana. 1: 139–146. 1946.
(11) BOYD, W. L. A Clinical Study of "White Heifer Disease." Cornell Vet., 34: 337–345. 1944.
(12) BRANDT, G. W. Achondroplasia in Calves. J. Heredity, 32: 183–186. 1941.
(13) CARMICHAEL, J. "Bull Dog" Calf in African Cattle. Nature, 131: 878. 1933.
(14) COLE, C. L., AND MOORE, L. A. Hydrocephalus, a Lethal in Cattle. J. Agr. Research, 65: 483–491. 1942.
(15) CREW, F. A. E. The Significance of an Achondroplasia-like Condition met with in Cattle. Proc. Roy. Soc., 95B: 228–254. 1923.
(16) CREW, F. A. E. The Bull-Dog Calf: A contribution to the Study of Achondroplasia. Proc. Roy. Soc. Med., 17: 39–57. 1924.
(17) DEAKIN, A. Field Fertility Tests and Causes of Sterility of Bulls. Dominion of Canada, Dept. Agr. mimeo. pub., 1–26. 1943.
(18) DEAKIN, A., MUIR, G. W., SMITH, A. G., AND MACLELLAN, A. S. Hybridization of Domestic Cattle and Buffalo (Bison Americanus). Dominion of Can., Dept. Agr. mimeo. pub., 1–10. 1941.
(19) DEGROOT, T., AND NUMANS, S. R. Over de Erfelijkheid der Impotentia Coeundii bij Stieren. Tijdschr. V. Dierjenecskunde, 71: 372–379. 1946. (Abs., Vet. Bull., 17: 552. 1947; Animal Breeding Abstracts, 15: 24. 1947.)
(20) DINKHAUSER, F. Mehr Milch durch früheres Zulassen der Rinder. Forschungsdienst., 17: 466–470. (abs., Animal Breeding Abstracts, 15: 100. 1947.)
(21) DORLAND, W. A. N. The American Illustrated Medical Dictionary. 20th Ed. W. B. Saunders Co., Philadelphia. 1941.
(22) DOWNS, W. G. An American "Dexter Monster." Anat. Record, 37: 365–372. 1928.
(23) EATON, O. N. A Summary of Lethal Characters in Animals and Man. J. Heredity, 28: 320–326. 1937.
(24) ECKLES, C. H. A Study of Breeding Records of Dairy Herds. Minn. Agr. Expt. Sta. Bull. 258. 1929.
(25) EISELE, F. Angeborne Haarlosigheit bei Kälbern der Schwarzbunten Niederungszucht als Auswirkung einer Letalfaktors. Züchtungskunde, 11: 432–437. 1936.
(26) EDITOR. Relationship between Hairless Calves in California and Texas herds. J. Heredity, 26: 355–356. 1935.
(27) ELY, F., HULL, F. E., AND MORRISON, H. B. Agnathia, a New Bovine Lethal. J. Heredity, 30: 105–108. 1939.
(28) ERIKSSON, K. Hereditary Forms of Sterility in Cattle. Hakan Ohlssons Boktryckeri, Lund, 1943.
(29) FINCHER, M. G. Methods of Increasing Fertility in Domestic Animals. Am. Soc. Study of Sterility Trans., 1–17. 1946.
(30) FINCHER, M. G., OLAFSON, P., AND FERGUSON, J. Sterility in Bulls. Cornell Vet., 32: 407–423. 1942.
(31) FINCHER, M. G., AND WILLIAMS, W. L. Arrested Development of the Muellerian Ducts Associated with Inbreeding. Cornell Vet., 16: 1–19. 1926.
(32) GILMORE, L. O. Unpublished data. Minn. Agr. Expt. Sta.
(33) GOLDSMITH, W. M. The Catlin Mark. J. Heredity, 13: 69–71. 1922.
(34) GOWEN, J. W. Results of Progress on Animal Husbandry Investigations in 1917. Maine Agr. Expt. Sta. Bull. 274. 1918.
(35) GREGORY, P. W., MEAD, S. W., AND REGAN, W. M. A New Type of Recessive Achondroplasia in Cattle. J. Heredity, 33: 317–322. 1942.
(36) GREGORY, P. W., MEAD, S. W., AND REGAN, W. M. Heredity Congenital Lethal Spasms in Jersey Cattle. J. Heredity, 35: 195–200. 1944.

(37) Gregory, P. W., Regan, W. M., and Mead, S. W. Evidence of Genes for Female Sterility in Dairy Cows. J. Genetics, **30**: 506–517. 1945.

(38) Grüneberg, H. Two New Mutant Genes in the House Mouse. J. Genetics, **45**: 22–28. 1943.

(39) Hadley, E. B. Congenital Epithelial Defects of Calves. J. Heredity, **18**: 487–495. 1927.

(40) Hadley, F. B., and Cole, L. J. Inherited Epithelial Defects in Cattle. Wisc. Agr. Expt. Sta. Research Bull. 86. 1928.

(41) Hallquist, C. Ein Fall von Letalfaktoren beim Schwein. Hereditas, **18**: 215–224. 1933.

(42) Hart, F. W. White Heifer Disease. Vet. Record, **51**: 63. 1939.

(43) Hayden, C. C. A Case of Twinning in Dairy Cattle. J. Heredity, **13**: 22–24. 1922.

(44) Heizer, E. E., and Hervey, M. C. Impacted Molars—a new Lethal in Cattle. J. Heredity, **28**: 123–128. 1937.

(45) Hilder, R. A., Fohrman, M. H., and Graves, R. R. Relation of Various Factors to the Breeding Efficiency of Dairy Animals and to the Sex Ratio of the Offspring. J. Dairy Sci., **27**: 981–992. 1944.

(46) Holze, J. Zwillings—Vererbung in der Rinderzucht der Oldenburger Herdbuch-Gesellschaft. Diss. Hanover, 1942. (abs., Animal Breeding Abstract, **11**: 95. 1943.)

(47) Houck, J. W. Hydrocephalus in Lower Animals: Congenital Occurrence in a Calf and an Albino Rat. Anat. Record, **45**: 83–106. 1930.

(48) Hughes, E. H., and Hart, H. Defective Skulls Inherited in Swine. J. Heredity, **25**: 111–115. 1934.

(49) Hull, F. E., Dimoch, W. W., Ely, F., and Morrison, H. R. Reproductive Efficiency in Dairy Cattle. Ky. Agr. Exp. Sta. Bull., 402. 1940.

(50) Hunsaker, L. R., and Gilmore, L. O. Unpublished data. Minn. Agr. Expt. Sta.

(51) Hutt, F. B. Bovine Quadruplets. J. Heredity, **21**: 339–348. 1930.

(52) Hutt, F. B. Inherited Lethal Characters in Domestic Animals. Cornell Vet., **24**: 1–25. 1934.

(53) Hutt, F. B. A hereditary Lethal Muscle Contracture in Cattle. J. Heredity, **25**: 41–46. 1934.

(54) Hutt, F. B. Some Hereditary Abnormalities of Domestic Animals. Cornell Vet., **36**: 180–194. 1946.

(55) Hutt, F. B., and Frost, J. N. Hereditary Epithelial Defects in Ayrshire Cattle. J. Heredity, **39**: 131–137. 1948.

(56) Ilancic, D. Ein neuer Letalfaktor beim Rind. Züchtungskunde, **15**: 129–133. 1940.

(57) Jewell, F. M. Sex Ratios in Foetal Cattle. Biol. Bull., **41**: 259–271. 1921.

(58) Johansson, I. The Sex Ratio and Multiple Births in Cattle. Z. f. Zuchtung, **B24**: 183–268. 1932.

(59) Johansson, I. Variations in the Manifestation of Lethal Characters in the Swedish Breeds of Cattle. Proc. 7th Intern. Genetic. Congr., 144. 1939.

(60) Johansson, I. Reduced Phalanges and Curly Coat; Two Mutant Characters in Native Swedish Cattle. Hereditas, **28**: 278–288. 1942.

(61) Johnson, L. E. "Streamlined" Pigs; a new Legless Mutation. J. Heredity, **31**: 239–242. 1940.

(62) Käb, E. Untersuchungen über die Vererbung von Fruchtbarkeit und Unfruchtbarkeit beim gelben Frankvieh. Dissertation, Univ. Muenchen, 1937.) (abs., Animal Breeding Abstracts, **6**: 200. 1938.)

(63) Keeler, C. E. "Parted Parietals" in Mice. J. Heredity, **21**: 19–20, 83. 1930.

(64) Knott, J. C. A Study of the Gestation Period of Holstein-Friesian Cows. J. Dairy Sci., **15**: 87–98. 1932.

(65) Kobozieff, N., Pomriaskinsky-Kobozieff, N. A., and Dupont, A. Génétique et Stérilité. Record Méd. vét., **119**: 49–56. 1943. (abs., Animal Breeding Abstracts, **13**: 69. 1945.)

(66) KOCH, W. Uber die wirtschafliche Bedeutung der Zwillingsgeburten beim Rind. Süddtsch. Landw. Tierz., 27: 413–415. 1933. (abs., Animal Breeding Abstracts, 2: 12. 1934.)

(67) KRALLINGER, H. E. Bemerkungen, zu der Arbeit "Ein neuer Letalfaktor beim Rinde" von D. Ilancic. Zuchtungskunde, 15: 133–134. 1940.

(68) KROON, H. M., AND VAN DER PLANK, G. M. Enkele Sub-letaalfactoren. Bij Tijdschrift voor Diergeneeskunde Huisdieren in Nederland. 58: 681–694. 1931.

(69) KUPPUSWAMI, P. S. Some Observations on the Incidence and Inheritance of Imperforate Anus in Ganjam Calves. Indian J. Vet. Sci., 7: 305–308. 1937.

(70) LAGERLÖF, N. Ein Beitrag zur Sterilität in der Rinderzucht. Z. f. Zuchtung., B32: 47–93. 1935. (Translated into German by Bass, E., and Bass, E., Jr.)

(71) LAGERLÖF, N. Hypoplasia of the Genitals in Cattle as a Cause of Sterility. Proc. 5th Northern Vet. Congr., Copenhagen. 1939. (abs., Cornell Vet., 31: 92. 1941.)

(72) LALONDE, L. M. A New Type of Bovine Agnathia. J. Heredity, 31: 80–81. 1940.

(73) LANDAUER, N., AND DUNN, L. C. Studies on the Creeper Fowl. J. Genetics, 23: 397–413. 1930.

(74) LERNER, M. Lethal and Sublethal Characters in Farm Animals. J. Heredity, 35: 219–224. 1944.

(75) LJUTIKOW, K. M. The Lethal Factor of Swiss Horned Cattle. Biol. Zhur., 1: 21–50. 1932. (Translated by M. H. Haydak.)

(76) LJUTIKOW, K. M. Breeding within the Family of the champion cow "Zolotaja." (Translated title) Prokl. Zivotn., 25–29. 1934. (Abs., Animal Breeding Abstracts, 3: 369. 1935.)

(77) LJUTIKOW, K. M. Hereditary Preponderance of Males Among the Progeny of Some Sires. (Translated title) Prob. Zivotn., 2: 49–51. 1935. (Abs., Animal Breeding Abstracts, 3: 369. 1935.)

(78) LJUTIKOW, K. M. Achondroplastic Micromelia in Jaroslav Large Horned Cattle. Biol. Zhur., 6: 413–434. 1937. (Translated by M. H. Haydak.)

(79) LUSH, R. H. Inheritance of Twinning. J. Heredity, 16: 273–279. 1925.

(80) MEAD, S. W., GREGORY, P. W., AND REGAN, W. M. Deleterious Recessive Genes in Dairy Bulls Selected at Random. Genetics, 31: 574–588. 1946.

(81) MEAD, S. W., GREGORY, P. W., AND REGAN, W. M. A Recurrent Mutation of Dominant Achondroplasia in Cattle. J. Heredity, 37: 183–188. 1946.

(82) MOHR, O. L. Dodbringende arvefactor hos husdyr og mennesker. Naturens Verden, 14: 1–31. 1930.

(83) MOHR, O. L., AND WRIEDT, C. Hairless, a New Recessive Lethal in Cattle. J. Genetics, 19: 315–336. 1928.

(84) MOHR, O. L., AND WRIEDT, C. Short Spine, a New Recessive Lethal in Cattle; with a Comparison of the Skeletal Deformities in Short-spine and in Amputated Calves. J. Genetics, 22: 279–297. 1930.

(85) MOORE, C. R. Gonad Hormones and Sex Differentiation. Am. Naturalist, 78: 97–130. 1944.

(86) MÖRCH, E. T. Achondroplasia is Always Hereditary and is Inherited Dominantly. J. Heredity, 31: 439–444. 1940.

(87) MORGAN, R. F., AND DAVIS, H. P. Influence of Age of Dairy Cattle and Season of the Year on the Sex Ratio of Calves and Services Required for Conception. Neb. Agr. Expt. Sta. Research Bull. 104. 1938.

(88) MURRAY, A. J. Diseases of the Digestive Organs. Diseases of Cattle, Rev. Ed., U. S. Govt. Printing Office. 31–32. 1942.

(89) NEWTON, O. R. Esterilidad de la vaca por adiposis de los organos genitals. J. Agron. Vet., Univ. B. Aires. 433–444. 1939. (Abs., Animal Breeding Abstracts, 11: 96–97. 1943.)

(90) NICKERSON, W. S. Achondroplasia in a Calf with a Thymus in Place of a Thyroid J. Lancet, 27: 7–10. 1917.

(91) NIELSEN, J. Iagttagelser over Indov hos Husdyr. Nord. Jordbrugsforskning, 5 and 6: 204–217. 1943. (Abs., Animal Breeding Abstracts, 14: 198, 224. 1946.

(92) PALUMBO, V. On Some Cases of Multiple Births. (Translated title.) Clin. vet. (Milano), 57: 232–235. 1934. (Abs., Animal Breeding Abstracts, 3: 372–373. 1935.)

(93) PATNAIK, K. S. Sterility due to Imperforate Os Uterus in Bovines. Indian Vet. J., 19: 249–251. 1943.

(94) PEARL, R. A Case of Triplet Calves with some General Considerations Regarding Multiple Gestation in Normally Uniparous Animals. Maine Agr. Expt. Sta. Rept., Bull. 204. 1912.

(95) PFAU, K. O., BARTLETT, J. W., AND SHUART, C. E. A Study of Multiple Births in a Holstein-Friesian Herd. J. Dairy Sci., 31: 241–254. 1948.

(96) PHILLIPS, R. W., TOLSTOY, I. A., AND JOHNSON, R. G. Yaks and Yak-cattle Hybrids in Asia. J. Heredity, 37: 163–170, 207–215. 1946.

(97) PUNNETT, R. C. The Experiments of T. H. Riches Concerning the Production of Monsters in Cattle. J. Genetics, 32: 65–72. 1936.

(98) RANSTEAD, J. M. The Inheritance of "Parrot-beak" in New Zealand Milking Shorthorns. N. Z. J. Sci. and Tech., 28 (3): 206–216. 1937.

(99) REGAN, W. M., MEAD, S. W., AND GREGORY, P. W. An Inherited Skin-defect in Cattle. J. Heredity, 26: 357–362. 1935.

(100) REMMERS, H. Erblich bedingte Vordergliedmassenverkrummung des Rindes in eines Schwartzbundzucht Nordwestdeutschlands. Diss. Tierärztl. Hochsch. Hannover, 32 pp. (Abs., Animal Breeding Abstracts, 8: 124. 1948.)

(101) RIEMERSCHMID, G., AND QUINLAN, J. Further Observations on the Scrotal Skin Temperature of the Bull, with Some Remarks on the Intra-Testicular Temperature. Onderstepoort J. Vet. Sci. and Animal Ind., 17: 123–140. 1941.

(102) ROBERTS, J. A. F. The Inheritance of a Lethal Muscle Contracture in the Sheep. J. Genetics, 21: 57–69. 1929.

(103) RUZHEVSKY, A. B. Ankylosis and Crooked Forelegs—A New Semilethal Hereditary Factor in Friesian Cattle (Translated title). B l. Zhur., 7: 547. 1938.

(104) SCHÄPER, W. Konstitutionsforschung und Krankheitsbekämpfung in der Tierzucht. Z. f. Züchtung, B35: 1–88. 1936.

(105) SEATH, D. M., AND STAPLES, C. H. Some Factors Influencing the Reproductive Efficiency of Louisiana Herds. (abs.) J. Dairy Sci., 24: 510. 1941.

(106) SELIGMAN, C. G. Cretinism in Calves. J. Path. and Bact., 9: 311–322. 1904.

(107) SELLERS, A. F. Personal communication. 1948.

(108) SHAW, A. O. A Skull-defect in Cattle. J. Heredity, 29: 319–320. 1938.

(109) SHRODE, R. R., AND LUSH, J. L. The Genetics of Cattle. Advances in Genetics, 1: 209–261. 1947.

(110) SISSON, S., AND GROSSMAN, J. D. The Anatomy of the Domestic Animals. 3rd Ed. Rev., W. B. Saunders Co., Philadelphia. p. 599. 1938.

(111) SNYDER, L. H. Principles of Heredity. D. C. Heath and Co. Chicago. 80 p.p. 1935.

(112) SPIELMAN, A. A., HILL, O. J., AND MCCULLOCH, E. C. Congenital Muscular Contracture and Ankylosis in Jersey Cattle. (abs.) J. Dairy Sci., 27: 655. 1944.

(113) SPIELMAN, A. A., AND JONES, L. R. The Reproductive Efficiency of Dairy Cattle. J. Dairy Sci., 22: 329–334. 1939.

(114) SPRIGGS, D. N. White Heifer Disease. Vet. Record, 58: 405, 415–418. 1946.

(115) STANG, V. Gehäuftes vorkommen von erblicher allgemeiner Gelenkverkrümmung in Ver binding mit Gavenspalt beim Rind. Z. Tierzücht. Zuchtungsbiol., 46: 280–284. 1940.

(116) SURRARRER, T. C. Bulldog and Hairless Calves. J. Heredity, 34: 175–178. 1943.

(117) SWETT, W. W., MATTHEWES, C. A., AND GRAVES, R. R. Early Recognition of the Freemartin Condition in Heifers Twinborn with Bulls. J. Agr. Research, 61: 587–623. 1940.

(118) TAUSSIG, S. The Problem of Fertility in Dairy Cattle and its Improvement through Breeding. Inter. Rev. Agr., 37: 256T–261T. 1946.
(119) TEUNISSEN, G. H. B. Steriliteit bij Stieren. Tijdschr. Diergeneesk., 71:595–608. 1946.
(120) TRIMBURGER, G. W., AND DAVIS, H. P. Predictability of Breeding Efficiency in Dairy Cattle from their Previous Conception Rate and from their Heredity. J. Dairy Sci., 28: 659–669. 1945.
(121) TUTT, J. F. D. Letter to the Editor. Vet. Record, 51: 92. 1939.
(122) VEIGA, J. S. Flexed Limbs, a Sub-lethal, Simple Recessive, Hereditary Factor in the Gir and Indo-Brazil Zebus. (Translated title.) Rev. faculdade med. vet. S. Paulo, 3: 101–108. 1945. (Abs., Animal Breeding Abstracts, 14: 224–225. 1946.)
(123) WAGENER, H. Untersuchungen über die Trächtigkeitsdauer in einer Braunviehherde. Sterilitat und Vererbung. Deut. tierarztl. Wochschr., 40: 761. 1932.
(124) WARD, A. H. Calf Wastage and Nutritional Survey. 22nd Ann. Rept. New Zealand Dairy Bd., Invista House, Wellington, N. Z. Pp. 14–21. 1946.
(125) WARREN, T. R., AND ATKESON, F. W. Inheritance of Hernia. J. Heredity, 22: 345–352. 1931.
(126) WEINKOPFF, P. Eine Hemmungsmissbildung bei einem Kalb mit Mikrognathia und Brachymelie. Berliner tierärztl. Woschschr., 43: 62–63. 1927.
(127) WHITE, G. C., RETTGER, L. E., AND MCALPHINE, J. G. Infectious Abortion. Conn. (Storrs) Agr. Expt. Sta. Bull. 123. 1924.
(128) WILLE, R. Ueber "Fruhreife" und ihre Bedeutung für die Rinderzucht. Wochschr. Wein. 1–3. 1944. (Abs., Animal Breeding Abstracts 12: 196. 1944.)
(129) WILLIAMS, W. L. Studies in Teratology. Cornell Vet., 21: 25–56. 1931.
(130) WILLIAMS, W. L. The Problem of Teratology in Clinical Veterinary Medicine. Cornell Vet., 26: 1–33. 1936.
(131) WILLIAMS, W. L. The Diseases of the Genital Organs of Domestic Animals. 2nd Ed. Published by the Author, Ithaca, N. Y. p. 20. 1939.
(132) WILSON, J. The Origin of the Dexter-Kerry Breed of Cattle. Proc. Roy. Dub. Soc. N.S. 12: 1–17. 1909.
(133) WINTERS, L. M. Animal Breeding. 4th Ed. John Wiley and Sons. New York. P. 140. 1948.
(134) WINTERS, L. M., GREEN, W. W., AND COMSTOCK, R. E. Prenatal Development of the Bovine. Minn. Agr. Expt. Sta. Bull. 151. 1942.
(135) WIPPRECHT, C., AND HORLACHER, W. R. A Lethal Gene in Jersey Cattle. J. Heredity, 26: 363–368. 1935.
(136) WOODWARD, T. E., AND GRAVES, R. R. Results of Inbreeding Grade Holstein-Friesian Cattle. U. S. Dept. Agr. Tech. Bull 927. 1946.
(137) WRIEDT, C. Letale Faktoren. Zeit. Zücht., Reihe B, 3: 223–230. 1925.
(138) WRIEDT, C. Heredity in Livestock. MacMillan and Co., Ltd., London. Pp. 131–138. 1930.
(139) WRIEDT, C., AND MOHR, L. Amputated, a Recessive Lethal in Cattle, with a Discussion on the Bearing of Lethal Factors on the Principles of Livestock Breeding. J. Genetics, 20: 187–215. 1928.
(140) YAPP, W. W. A Case of Intersex in Dairy Cattle. (abs.) J. Dairy Sci., 30: 552. 1947.
(141) YAPP, W. W. Inheritance—A Factor in Breeding Failures. Minutes Dairy Cattle Breeding Research Council, Purebred Dairy Cattle Assoc., Sept. 12, 1947.
(142) ZAWADOWSKY, M. M. Zebu-Yak Hybrids. J. Heredity, 22: 296–313. 1931.

METHODS OF APPROACHING THE PROBLEM OF INFERTILITY[1]

J. F. SYKES

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In the preceding discussions of infertility, the reader must have been impressed by the absence of concrete information which would enable dairymen to prevent or correct reproductive disturbances in cattle. While there is considerable information on the effect of genetic, pathological, nutritional and physiological factors on reproductive processes, the applicability of this information to the problem of infertility, as it is seen under farm conditions, has not been determined with any degree of certainty.

It has been shown, for instance, that several nutritional deficiencies interfere with reproduction under experimental conditons. These marked deficiencies do not occur frequently under practical conditions, however, and usually the condition of the animal indicates that its general nutrition was at fault before disturbances in reproduction are evident. How important then are the so-called marginal nutrient deficiencies as factors in infertility? This has not been determined. In the pathological field, for example, vaginitis is a condition that occurs very frequently in cattle, yet the causative organism is unknown. Moreover, neither the factors which predispose to the occurrence of vaginitis nor its actual importance as a cause of infertility have been determined. Many similar examples could be cited.

In the first place, therefore, the whole problem of infertility seems to suffer from a lack of a critical experimental approach in many instances, and a great deal of detailed experimental work will be necessary in the various fields of study before much progress will be made. The need for adequate controls already has been mentioned in the discussion by Asdell (1). Every control that can be devised should receive adequate consideration because of the multiplicity of the factors that appear to affect reproduction. It would seem particularly important to have disease-free units, in which groups of cattle are maintained free from contact with other cattle. In so far as possible, groups should be studied under comparable conditions of season, environment and management.

Another important phase in the study of infertility is the need for more specific definitions and also for more numerous and detailed criteria for evaluating the effects of experimental procedures.

Some agreement on what constitutes infertility should be reached. Many criteria, including viability of the calf after birth, parturition difficulties, and others, have been used in the past as measures of fertility. In most instances, it would seem that the essential reproductive processes are reasonably normal if a living offspring is born. The actual fecundity, i.e. the ability to produce viable ova and sperm, would seem to be an even more adequate measure of actual

[1] Based upon a paper presented in the symposium on Reproductive Problems of Dairy Cattle at the 43rd Annual Meeting.

fertility. While it may be necessary to be somewhat arbitrary, some general agreement on a definition of infertility should be reached.

In this connection, the development and general acceptance of some index of fertility should be attempted. At present reliance is placed largely on services per conception or percentage of pregnancies for evaluating fertility. This is not always satisfactory. With this criterion, it is difficult to assess the contribution of a completely infertile animal to the population being studied, and it fails to take into account those animals in which conception actually occurs but in which development of the fertilized eggs does not proceed to the point where pregnancy can be detected. An index similar to that proposed by Williams (3) and more recently used by Spielman and Jones (2) should be suitable for this purpose. With an index of this sort and by using dam and daughter comparisons or other criteria, a better measure of the ability of sires or cows to transmit good reproductive performance might be obtained. The inclusion of these data along with production data on pedigrees might be quite useful.

Lack of adequate criteria by which the effects of experimental techniques can be judged more accurately and in more detail is largely a result of insufficient basic physiological data. We have no adequate information on hormone levels in the blood of cattle nor on the effects of the various hormones on ovulation, spermatogenesis and activity and function of the various parts of the reproductive tract. Similarly, we have only scattered information on the histological and histochemical reactions of the various parts of the reproductive tract under various conditions and on the effects of these on sperm transport, fertilization, implantation and subsequent nourishment of the fetus. This state of affairs has arisen partly because of lack of suitable methods with which to attack the problem. Methods for quantitative analysis of hormones, an accurate method for the detection of ovulation, and means of following changes in the various parts of the reproductive tract are among the methods which must be developed if this basic information is to be obtained.

The specific problems on which work must be done in the various fields are very numerous. While it appears that basic physiological data are of prime importance in that progress in other fields will be restricted until means for making a detailed analysis of the responses of the reproductive organs is available, no one field of study need have absolute priority. Many of these studies could be carried concurrently. As a beginning at least, the following types of problems in the various fields of work are suggested as being among those which would give a fundamental understanding of the factors affecting reproduction.

Physiological studies

1. Development of chemical or biological methods for the quantitative estimation of hormones in the blood of cattle and of methods for determining secretion rates.

2. Detailed histological and histochemical studies on the various parts of the reproductive tract at all stages of development and under a variety of physiological conditions.

3. Studies on the factors affecting hormone levels and secretion rates, and variations in the different parts of the reproductive tract.

4. Studies on the underlying principles affecting ovulation and spermatogenesis by correlating hormone levels or other factors with these functions or by studying the responses to administered hormones.

5. The effects of changes in the reproductive tract on fertilization, implantation and subsequent nourishment of the embryo, livability and transport of sperm.

6. Studies of effect of season and environment on reproductive organs and on above reactions.

Pathological studies

Attention should probably de directed now to what are called the "non-specific" organisms and abnormalities, particularly vaginitis.

1. Surveys to determine incidence and relation to infertility.

2. Study of causative organism of vaginitis.

3. Inoculation experiments with organisms from infertile cows.

4. Studies to determine conditions which predispose to the invasion and pathogenicity of organisms.

5. Studies on the relation of heredity, nutrition, management and environment on resistance to disease.

Genetic studies

1. If it is not agreed that inheritance is an important factor in sterility, a further survey of available literature and a thorough study of existing records would help to settle this point.

2. Establish herds of high and low fertility by inbreeding or other means.

3. Studies on the above herds concerning hormone levels, disease resistance, nutritive requirements and other factors as they are related to infertility.

4. Surveys and investigations to determine whether high production is compatible with fertility and to determine the conditions which contribute to this discrepancy, if it exists.

Nutritional studies

1. Controlled studies on the effects of marginal deficiencies of specific nutrients on infertility.

2. Studies on effect of energy intake uncomplicated by specific deficiencies on reproduction.

3. Surveys of existing data and experiments to determine the effects of varying rates of growth.

4. The relation of the above factors on resistance to disease, hormone levels and other possible variables.

This work must be done largely with cattle. While experiments with laboratory animals can give important leads and, when done in conjunction with similar work with cattle, may reduce the numbers of cattle necessary for con-

clusive results, adequate experimentation with cattle must be done. Therefore, progress will be time-consuming and costly.

Organization of the work on a co-operative basis, therefore, would seem very desirable. The rearing of animals under experimental conditions and their subsequent placement on selected farms where their lifetime performance could be studied would multiply greatly the number of animals which could be studied and generally increase the number of factors which could be investigated during a given time interval. The establishment of a large central laboratory adequately staffed and financed by Federal and State funds and by the breed organizations should be considered, and inter-institution co-operation should be undertaken at eve y opportunity. Artificial-insemination units can play a large part in this program. These groups provide the only adequate set-up for studying the effects of various factors on reproduction in the bull. Work on this phase of the problem should be restricted largely to these groups, and every encouragement should be given to them to include a broader experimental approach in their work.

Where co-operative work is undertaken the interested parties should agree as to the priority of problems, the experimental design and the technics to be used for evaluation. Indeed, agreement on these latter items on an even wider basis and the establishment of technical guidance committees would be a highly advantageous step in the proper direction. It is only by an intensive, highly co-ordinated program that reasonably rapid progress will be made in solving the problem of infertility.

REFERENCES

(1) ASDELL, S. A. Hormones and the Treatment of Sterility in Dairy Cattle: A Review. J. Dairy Sci., 32: 45–59. 1949.

(2) SPIELMAN, ARLESS, AND JONES, I. R. The Reproductive Efficiency of Dairy Cattle. J. Dairy Sci., 22: 329–334. 1939.

(3) WILLIAMS, W. L. A Standard for Measuring the Reproductive and Dairying Efficiency of Dairy Cattle. Cornell Vet., 9: 204–213. 1919.

ASSOCIATION ANNOUNCEMENT

PAPERS FOR THE 1949 ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

The annual meeting of the American Dairy Science Association will be held June 21 to 23, 1949, at the University of Minnesota, University Farm, St. Paul. All members who are planning to present papers should submit the title of their paper accompanied by an abstract of not more than 200 words not later than March 15 to the chairman of the program committee of their respective section. The committee chairmen are as follows:

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The general program committee feels that in order to make it possible for more members to participate in the program no member should present more than two papers. No title will be considered that is not accompanied by a suitable abstract. It also is hoped that more contributions will be received from senior staff members and from the laboratories of industry.

Because of the difficulties encountered in showing slides, it is recommended that each speaker distribute mimeographed copies of his data, together with a brief summary of his paper.

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ABSTRACTS OF LITERATURE

ANIMAL DISEASES

W. D. POUNDEN, SECTION EDITOR

1. Penicillin therapy in chronic bovine mastitis. II. Penicillin levels in the udder during treatment. R. A. PACKER, Iowa State College, Ames. Am. J. Vet. Research, **9**, 32: 259–263. July, 1948.

Penicillin in saline solution was injected into udders. The data indicated that less penicillin at 12 hr. after injection had left the quarters producing the greater quantities of milk. Differences were minor after a period of 24 hr. There were no marked differences between the quantities of penicillin which remained in the udder secretions 24 hr. after injection when 25,000 and 200,000 units were used. Similar levels were obtained 12 hr. post-injection in secretions from a staphylococcic infected quarter and a non-infected one. Levels of penicillin in udder secretions were fairly similar regardless of the time during milking when the samples were collected. Frequency of injection influenced the levels maintained in udder secretions more than the quantities injected. W. D. Pounden

2. Penicillin therapy in chronic bovine mastitis. III. Treatment of mastitis. R. A. PACKER, Iowa State College, Ames. Am. J. Vet. Research, **9**, 32: 264–269. July, 1948.

Little difference in results was obtained in the treatment of streptococcic udder infections between 1 or 2 injections of penicillin at 24 hr. intervals and 3 or 4 injections at 12 hr. intervals. Average results were 83% for all cases using 25,000 to 200,000 units in 50.0 cc. saline solution. Successfully treated staphylococcic cases were 22% for 1 or 2 injections and 48% for 3 or 4 injections. W. D. Pounden

BUTTER

O. F. HUNZIKER, SECTION EDITOR

3. Apparatus for the molding of butter and like products. J. O'CONNELL. U. S. Patent 2,451,301. 20 claims. Oct. 12, 1948. Official Gaz. U. S. Pat. Office, **615**(2): 459. 1948.

A machine is described which continuously and automatically molds butter into various shaped and sized pieces. A number of identical molds rotate from beneath the filler to a member which discharges the product from the mold thence returning to the filling position again. R. Whitaker

Also see abs. no. 21.

CHEESE

A. C. DAHLBERG, SECTION EDITOR

4. Quality improvement in Canadian Cheddar cheese. W. H. SPROULE. Can. Dairy Ice Cream J., **27**, 7: 29–32. July, 1948.

The concentration of effort to improve Cheddar cheese should include (a) explicit information to the producer of sanitary methods of production and cooling of milk; (b) more extensive use of the single service milk filter on the farm; (c) checking of milk on the receiving platform, aided by reductase test taken at regular intervals; (d) adoption of an organized plan of sediment testing of milk and cheese; (e) more extensive use of filter strainers at the factory and (f) prevention of coal dust or about material getting into milk and curd during the manufacturing process. H. Pyenson

5. The manufacture of low-acid rennet-type cottage cheese. H. R. LOCHRY, Bureau of Dairy Ind., Agr. Research Admin. Southern Dairy Products J., **44**, 3: 84–85, 88–90, 92, 94. Sept., 1948.

Low-acid, rennet-type cottage cheese is a superior product. It may be manufactured by the following procedure: Set at 70 to 72° F. skim milk pasteurized by the holding method or the short-time method and add enough active starter (about 0.5 to 1%) to produce from 0.51 to 0.53% acidity in the whey by the time curd is to be cut. Add 1 ml. of rennet per 1,000 lb. of skim milk. Maintain uniform temperature. Cut the curd into half-inch cubes. Cover the curd with at least 2 inches of water at 115 to 120° F. and apply steam in the jacket of the vat to raise the temperature in 1 to 2 hr. to 110 to 120° F., or until the curd has the proper firmness when tested after dipping a sample in cold water. Stir the curd carefully to avoid breaking. Wash the curd with tap water and then with ice water. Drain for 1 hr. and add 1 lb. of salt per 1,000 lb. of skim milk. Hold in cooler at 32 to 40° F. for 4 hr. or until day of sale.

To each 100 lb. of curd add 1 lb. of salt, 30.5 lb. of pasteurized 18% cream, preferably homog-

enized, and enough 4.2% milk to produce the desired consistency. F. W. Bennett

6. New product developments leading to greater cheese sales. G. H. Wilster. Can. Dairy Ice Cream J., **27,** 6: 52–62. June, 1948.

The factors involved in the expansion of cheese sales are: (a) continued high consumer income and the desire by the consumer for good food of which cheese is one; (b) shortage of meat and meat products; (c) varieties of cheese other than Cheddar should be offered for sale; (d) cheese quality improvement and standardization of quality; (e) reduction in cost of production through developing economics in the manufacture and packaging of cheese and more efficient utilization of whey; (f) improved merchandising methods; (g) further education of consumer regarding the nutritional value of cheese and in the methods of using cheese to advantage in preparing menus; and (h) education of homemakers in methods of serving and caring for cheese in the home so that the product will have maximum palatability.
H. Pyenson

DAIRY BACTERIOLOGY

P. R. ELLIKER, SECTION EDITOR

7. A modification of the Voges-Proskauer test for rapid colorimetric determination of acetylmethylcarbinol plus diacetyl in the butter cultures. N. King. Dairy Inds., **8,** 9: 860–861. Sept., 1948.

A modification of the Ritter test for acetylmethylcarbinol plus diacetyl is described. Reagent A is a 30% aqueous solution of KOH. Reagent B contains 0.1 g. dicyandiamide and 4.0 g. α-naphthol in 10.0 ml. amyl alcohol and 50.0 ml. ethyl alcohol.

The test is performed as follows: To 2 ml. of the untreated culture are added 1 ml. of reagent A and 1 ml. of reagent B. The reaction is carried out in a wide test tube to obtain better contact with the air, or strictly speaking with the oxygen of the air, which may be regarded as the third reagent. The mixture is brought to about 30° C. in a water bath, held 30 minutes and repeatedly shaken. A more or less intense red-lilac coloration develops, depending on the content of acetylmethylcarbinol. The fluid then is filtered through a paper filter. The color intensity of the clear filtrate is compared with the intensity of a color standard which corresponds to a content of acetylmethylcarbinol of 2 mg. per 100 ml. of cultures. A dilution technic is described to aid in quantitative measurements. The composition and preparation of the color standard is described in detail. G. H. Watrous, Jr.

8. Grading milk with the resazurin test. N. S. Golding. Can. Dairy Ice Cream J., **27,** 7: 33, 82. July, 1948.

One of the official methods of grading milk in the 9th edition of *Standard Methods for Dairy Products* of the American Public Health Association will be the resazurin test. Prepared sterile vials have been made available by the Dairy Husbandry Department at the State College of Washington. The teaching of the resazurin test by a practical short course invites many questions and probably is the best way for field men and others to understand the work. H. Pyenson

9. Direct versus plate counts. L. D. Searing. Can. Dairy Ice Cream J., **27,** 7: 37–39. July, 1948.

The usual advantages and disadvantages of the direct microscopic count and the plate method of counting bacteria in milk are outlined. Some practical comparisons are given. On 129 samples, the average plate count was 20% higher than the average direct count. H. Pyenson

10. A combination of the resazurin test and the direct microscopic count for the bacteriological examination of milk. A. L. Bortree and R. D. Spencer, Mich. Agr. Expt. Sta., East Lansing. J. Milk and Food Technol., **11,** 5: 256–258, 268. Sept.–Oct., 1948.

A direct comparison of the resazurin test and direct microscopic count is not possible in checking the quality of milk. However, the authors suggest a combination of the resazurin test and direct microscopic count in checking the milk. All samples placed in class 1 by the reduction test in general showed a low bacterial count, while those samples placed in class 4 definitely were of low quality.

Apparently, the resazurin test could be used as a screening test to eliminate high quality milk samples from further examination. The test also may be useful in detecting low quality milk subject to further examination and field work. H. H. Weiser

11. Significance of coliform bacteria in pasteurized milk and milk products. M. P. Baker, Dept. of Dairy Ind., Iowa State College, Ames. Milk Plant Monthly, **37,** 8: 82–84, 95. 1948.

Coliform organisms consistently come into pasteurizing plants with the raw milk, and while they do not resist pasteurization, except rarely, there are a number of ways they can find their way around the pasteurizing process and into the pasteurized product. Their presence in the pasteurized product indicates that they got in

there after heating, which means unclean equipment or improper protection of the product against drip contamination, hand contact, etc. Their numbers in pasteurized products depend upon the amount of contamination and also on the amount of the growth that may have taken place in the product. Coliform count thus is an index to the sanitation in the plant, particularly in the handling after pasteurization.

G. M. Trout

12. The potentiating action of sulfonamides on the Brucella antibody-complement system. I. F. Huddleson, Mich. State College, East Lansing. Am. J. Vet. Research, **9**, 32: 277–285. July, 1948.

Previous work by the same author had shown that undiluted fresh serum or plasma from most normal as well as immune cattle contained specific antibodies which in combination with complement killed *Brucella* organisms. However, a similar effect could not be demonstrated in similar blood constituents from *Brucella*-infected cattle. Under certain conditions when complement was added to the latter serum or plasma, growth *in vitro* of the organisms was delayed. Further work showed that the temporary growth-inhibiting effect of sodium sulfonamide salts for *Brucella* organisms in suitable culture medium was enhanced to a bactericidal effect when fresh normal serum was added, but not when serum from infected animals was used. The failure of the latter serum is explained as being due to the prozone antibody phenomenon.

Experimentally produced brucellosis in guinea pigs was markedly alleviated by the feeding of 0.2 g. sulfadiazine, along with the intraperitoneal injection of normal or immune rabbit serum.

W. D. Pounden

Also see abs. no. 1, 2, 69, 70.

DAIRY CHEMISTRY

H. H. SOMMER, SECTION EDITOR

13. A synthesis of cis-11-octadecenoic and trans-11-octadecenoic (vaccenic) acids. K. Ahmad, F. M. Bumpus, and F. M. Strong, Dept. of Biochem., Univ. of Wis., Madison. J. Am. Chem. Soc., **70**, 10: 3391–3394. Oct., 1948.

The configuration of natural vaccenic acid (isolated from beef tallow) is *trans*-11-octadecenoic acid. Synthesis of the acid was accomplished readily with excellent yields by condensation of 1-octyne with 1-chloro-9-iodonane and conversion of the resulting 1-chloro-10-heptadecyne, via the nitrile, to 11-actadecynoic acid. Partial hydrogenation of the acetylenic bond in the latter produced only *cis*-11-octadecenoic acid which was isomerized to the *trans* form (vaccenic acid) with selenium.

Synthetic vaccenic acid was found to melt at 43–44° C. Natural vaccenic acid melts at 39° C., according to Bertram. The *cis* isomer melts at 10.5–12° C. The method of synthesis embraces the following reactions:

$$CH_3(CH_2)_5C \equiv CH + I(CH_2)_9Cl \xrightarrow[\text{liq. } NH_3]{Na} CH_3(CH_2)_5C \equiv C(CH_2)_9Cl$$

$$CH_3(CH_2)_5C \equiv C(CH_2)_9Cl \xrightarrow[KOH]{NaCN} CH_3(CH_2)_5C \equiv C(CH_2)_9COOH$$

$$CH_3(CH_2)_5C \equiv C(CH_2)_9COOH \xrightarrow[Ni]{H_2} CH_3(CH_2)_5CH = CH(CH_2)_9COOH$$

H. J. Peppler

14. A comparison of semi-monthly and monthly composite samples as a basis of paying for milk. E. O. Herreid, Univ. of Ill., Urbana. Milk Dealer, **37**, 10: 58–64. July, 1948.

Data are presented comparing fat test of semi-monthly and monthly composite samples. If preserved composite milk samples are kept in clean, sterile bottles at 50° F., or less, in good physical condition and free from mold growth and are properly prepared, sampled and tested by the Babcock procedure, semi-monthly composites yield slightly more milk fat than monthly composites. However, the difference is so small that testing can be done monthly without material injustice to the patron or to the plant. Semi-monthly and monthly composites can be reprepared and retested once, after holding for 48 hrs., and the results will be reasonably comparable with those secured from tests made at the end of the sampling period. Significantly lower results are apt to be obtained if composite samples are reprepared and retested a second or a third time.

C. J. Babcock

15. A procedure for determination of DDT in milk. D. E. H. Frear, Dept. of Agr. and Biol. Chem., Penn. State College. Milk Plant Monthly, **37**, 8: 96–99. Aug., 1948; Milk Dealer, **37**, 12: 58–62. Sept., 1948.

The author describes in specific detail the method of determining quantitatively the amount of DDT present in milk.

G. M. Trout

16. Manufacture of artificial textile fibers. A. Ferretti. (vested in Attorney General of U. S.)

U. S. Patent 2,450,889. 2 claims. Oct. 12, 1948. Official Gaz. U. S. Pat. Office, **615**(2): 357. 1948.

A textile fiber is produced by dissolving casein in a mixture of caustic alkali and Na and K silicates, spinning fibers from the mixture and then coagulating same with an acid.

R. Whitaker

Also see abs. no. 7, 40, 41.

DAIRY ENGINEERING

A. W. FARRALL, SECTION EDITOR

17. Color combinations—their importance to efficient, sanitary dairy products plants. A. C. TERRELL, A. C. Terrell Co., St. Louis, Mo. Southern Dairy Products J., **44**, 4: 40, 90–91, 98. Oct., 1948.

Paints for dairy plants should be selected to protect buildings and equipment and to safeguard the employees and add to their efficiency. Gloss enamel finishes last longer than flat paints, are washable and have greater reflection. Enamels should be selected for resistance to moisture, steam, oils, fats, acids and alkalies, to which they may be exposed. Colors which properly reflect or absorb light, have warmth or coolness, stimulate or relax to suit the location should be selected. Light gray is recommended for equipment to increase visibility. Color standards for safety should be observed, especially to call attention to hazards.

F. W. Bennett

18. Heating apparatus. D. D. PEBBLES. (assigned to Golden State Co.) U. S. Patent 2,452,260. 3 claims. Oct. 26, 1948. Official Gaz. U. S. Pat. Office, **615**(4): 988. 1948.

A heater for liquids, including food products like milk, is constructed of a tube into one end of which steam is admitted. The fluid to be heated is introduced directly into the flowing steam through a series of equally spaced tangentially directed jets which cause the liquid to spiral inwardly and to be discharged through the end of the tube opposite to the steam inlet.

R. Whitaker

19. Centrifugal separator. B. S. HUGHES. (assigned to Zaremba Co.) U. S. Patent 2,452,465. 1 claim. Oct. 26, 1948. Official Gaz. U. S. Pat. Office, **615**(4): 1038. 1948.

An entrainment separator for vacuum pans is described.

R. Whitaker

20. Filter. J. P. O'MEARA. (assigned to W. M. Sprinkman Corp.) U. S. Patent 2,452,486. 4 claims. Oct. 26, 1948. Official Gaz. U. S. Pat. Office, **615**(4): 1044. 1948.

A filter for fluids, such as water and milk, consisting of a series of horizontal disks, perforated and so arranged that the product passes slowly upward through pads of cloth, cotton, paper, etc., is described. Heavy particles collect on the plates rather than the pads.

R. Whitaker

21. Churn. W. RIVERS. U. S. Patent 2,452,492. 1 claim. Oct. 26, 1948. Official Gaz. U. S. Pat. Office, **615**(4): 1045. 1948.

A small vertical churn having an oscillating agitator supported on the bottom is described.

R. Whitaker

22. Dairy plants need pure, fresh air. CLYDE TOMPKINS, Reynolds Electric Co., Chicago, Ill. Milk Dealer, **37**, 10: 68–70. July, 1948.

The need for pure, fresh air in dairy plants is stressed. Enclosed or partially enclosed rooms can secure forced air circulation by: (a) air conditioning, whereby washed or filtered air of a desired temperature is forced into the room through ducts by blower type fans; (b) an exhaust fan, whereby a fan is located in an outer wall, usually near the ceiling of a room and there normally is an air intake near the floor of the room; (c) the use of free circulating fans which keep the air in the room in motion.

The types of free air circulating fans are: (a) the horizontal blowing fan which keeps the air in motion to a greater or less degree but leaves dead air spots in the room; (b) the horizontal, oscillating fan which blows a while in one direction and then automatically changes and blows it in another direction, the various currents set up by this action tending to neutralize each other and leave much of the air in the room stagnant; (c) the fan which blows upwards at high velocity, the air velocity, on striking the ceiling being transformed into an expanding turbulance which travels slowly along the ceiling, down the walls and up to the fan again. Tests have shown the latter type to be most effective.

The importance of air circulation in a refrigerated room also is discussed.

C. J. Babcock

Also see abs. no. 3.

DAIRY PLANT MANAGEMENT AND ECONOMICS

23. The need for standardization of operating methods in dairy processing plants. W. H. E.

REID, Univ. of Mo., Columbia. Southern Dairy Products J., **44,** 4: 45, 84–85, 87–88. Oct., 1948.

The following points have been considered by the most successful dairy plant operators in standardizing their operating methods: good will of consuming public based upon quality of product; efficiency of operation; feeling of personal responsibility and importance of all employees; character and integrity of employees; ability of employees to command respect and cooperation of other people; cooperation with health and control officials; convenience and sanitation of rest rooms, locker rooms and shower baths; air conditioning of plant; and good housekeeping to maintain the plant and equipment sanitary, attractive and in most efficient working order.

F. W. Bennett

24. What is any business worth? A. C. KIECHLIN, Public Accountant, Pompton Lakes, N. J. Ice Cream Rev., **31,** 3: 52, 54, 56. Oct., 1948.

The tangible net worth of the business may be arrived at quite readily by deducting from the current market value of the physical assets the value of all liabilities. The difference between these 2 values represent the current tangible net worth of the business.

The intangible value of the business is made up of good will and earning power. One method of arriving at a fair value for good will is to determine the average net profit, the average capital investment and the average return on the capital investment at 5% for the past 3 years of operation. Then subtract from the average net profit the average return on capital investment figured at 5%. Multiply the difference by 5, representing the "number of years purchase". The figure representing the number of years purchase may vary depending upon the length of time the business has been in operation, the trend in profits for the business and general business conditions. Usually a figure between 2 and 10 is used as the number of years purchase. The value of the business as determined by this procedure, would be the sum of the tangible net worth plus the value arrived at for good will.

Another procedure for arriving at the value of good will is to multiply the average earnings for the business during the past 5 years by 10 and deduct from this figure the value of the assets. The difference between these 2 values represents the value of good will.

Anyone who is contemplating the sale of his business would do well to figure the value of good will by each method presented before determining the value to be placed on the business.

W. J. Caulfield

25. Co-operatively built plant. ANONYMOUS. Milk Dealer, **37,** 9: 50–51, 71. June, 1948.

Fourteen independent milk dealers in Springfield, Mass. pooled resources to construct a jointly operated $350,000 pasteurizing plant. Carrying on processing operations in the new plant under the name of Dairy Center, Inc., the 14 individual milk dealer-owners are continuing to distribute co-operatively processed dairy products independently under their own firm names in their own communities.

C. J. Babcock

26. Where do we go from here? A. R. STEVENS, National Dairy Products Corp., New York City. Milk Dealer, **37,** 9: 168–174. June, 1948.

A discussion of the opportunities in the dairy industry and the factors that challenge these opportunities is presented. The following are mentioned as some of the things that should be included in the programs of all parts of the dairy industry: (a) thorough and consistent dissemination of information regarding the economics of the dairy business; (b) a fair and reasonable profit without tampering or interfering with the quality of dairy products; (c) educate dealers to retail dairy products to the public at fair mark-ups; (d) make dairy products convenient to the public to buy, which means distributing them through every possible outlet; (e) surround the sale and consumption of dairy products with an atmosphere of cleanliness and sanitation; and (f) in addition to nutrition, give greater emphasis to the goodness and appetite appeal of dairy products.

C. J. Babcock

27. Cutting operating cost through better management. E. L. BAUM, Iowa State College, Ames. Milk Dealer, **37,** 12: 53, 75. Sept., 1948.

The only recourse left to the dairy plant operator in meeting the increased cost of his fluid milk supply, as well as the increased cost of equipment, labor, etc., is to cut costs through better management. To do this, it is necessary to: (a) keep closer records of all milk utilization and butterfat losses, container costs, etc. (b) keep daily plant records in order to locate excess plant labor and to show where it can be shifted. (c) study plant operations to observe labor inefficiencies and inefficiencies caused by improper placement of equipment. (d) use straight-line methods of machinery depreciation.

C. J. Babcock

Also see abs. no. 42, 48, 51, 52, 53, 54.

FEEDS AND FEEDING

W. A. KING, SECTION EDITOR

28. Seasonal variations of carotene and other nutritionally important constituents in the two pasture grasses Dallis and Carpet. J. R. Kuppers, L. L. Rusoff, and D. M. Seath. J. Agr. Research, **77,** 2: 55–63. July 15, 1948.

A study was made of the seasonal trends of some nutritionally important constituents of 2 species of pasture grasses, Carpet (*Axouopus affinis*) and Dallis (*Paspalum dilatatum*) during a growing season of 9 months. On the average and over the greater part of the season, Dallis grass had a higher content of crude carotene, crude protein, lignin, cellulose, calcium, phosphorus, ash and moisture. During the hot months of Aug. and Sept., Carpet grass was as good as, or better than, Dallis grass as a source of carotene, protein, calcium and phosphorus. Seasonal variations in composition were less for Carpet grass than for Dallis grass. Significant correlations were found between crude carotene and crude protein in both Carpet grass (+0.52) and Dallis grass (+0.73). H. Pyenson

29. Feed all the colostrum. N. N. Allen, Univ. of Vt., Burlington. Hoard's Dairyman, **93,** 21: 805. Nov. 10, 1948.

Three groups of calves were used to determine to what extent stored colostrum could replace marketable milk for calf raising. Group I (control group) was fed the dam's milk for 10 d. and then changed to mixed milk. Group II was fed fresh colostrum the first d. The remainder of the colostrum produced through the third d. after parturition was frozen and fed during the first 10 d. of the calf's life in the order that it was produced. Then the calves were put on mixed milk. Groups I and II were fed skim milk from 5 to 9 weeks of age. Group III was handled like the second for the first 10 d., after which they were fed stored colostrum until 9 weeks of age. The all-colostrum calves (group III), which had averaged 5.5 lb. lighter at birth, averaged 3 lb. heavier at 9 weeks of age. Group II, which averaged 0.8 lb. lighter than the check lot at birth, averaged almost 2 lb. heavier at 9 weeks. While the calves of all 3 groups were thrifty and husky, the all-colostrum animals had the sleekness typical of calves fed whole milk. Colostrum can replace an equal amount of salable milk when used properly. J. B. Frye, Jr.

Also see abs. no. 68.

GENETICS AND BREEDING

N. L. VAN DEMARK, SECTION EDITOR

30. Hyaluronidase activity of spermatozoa. O. Hechter, and Z. Hadidian, Worcester Foundation for Experimental Biology and Tufts Medical School. Endocrinology, **41,** 2: 204. Aug., 1947.

Rabbit semen, collected with an artificial vagina, was utilized and in all instances the semen was studied within 24 hr., and in most instances within 1 hr., after collection. The semen sample was centrifuged, and successive saline washings made of the spermatozoa followed by centrifugation. Hyaluronidase activity was measured by either a viscometric or a skin spreading method of assay. Using the spreading method of assay, it consistently was observed that the hyaluronidase concentration in the second, third, fourth, fifth, and sixth washings remained nearly equivalent to the original seminal plasma. In the seventh washing, the enzyme activity fell off at least 10-fold. It was concluded that the hyaluronidase activity obtained in the washings of sperm either must be derived from the spermatozoa or closely associated with them. Ralph P. Reece

31. Motility of bovine spermatozoa. C. K. Rao and G. H. Hart, Univ. of Calif. Am. J. Vet. Research, **9,** 32: 286–290. July, 1948.

Motility of sperm normally is initiated in the ampullae but can be induced in sperm from deeper regions of the reproductive tract. It is the outcome of admixture of the sperm with accessory secretions rich in electrolytes and the influence of a series of functions of the organs of the reproductive tract. Examination and evaluation of bovine semen as regards motility are discussed in detail. W. D. Pounden

Also see abs. no. 67.

HERD MANAGEMENT

H. A. HERMAN, SECTION EDITOR

32. Teat draining tube. H. A. Alcorn. U. S. Patent 2,450,217. 1 claim. Sept. 28, 1948. Official Gaz. U. S. Pat. Office, **614**(4): 982. 1948.

A tube having one end tapered to a blunt point for inserting into a cow's teat to facilitate drainage of milk is described. Spiral channels on the surface permit the milk to flow between the teat wall and the device proper. R. Whitaker

33. Escharotic solution for dehorning calves. J. E. Guthrie. (assigned to Hess and Clark, Inc.) U. S. Patent 2,450,953. 2 claims. Oct.

12, 1948. Official Gaz. U. S. Pat. Office, **615** (2): 372. 1948.

Calves may be dehorned by antimony chloride dissolved in nitrocellulose lacquer.

R. Whitaker

34. Cutting production costs. ANONYMOUS. Milk Dealer, **37,** 12: 48–49, 100–101. Sept., 1948.

The experiments being conducted on an all-electric dairy farm by the Univ. of Wis. College of Agriculture in cooperation with the Wis. Utilities Assoc. to determine means of reducing labor on dairy farms are described. Principal equipment are a barn cleaner, silo unloader, silage dispensing cart, cow trainers, ventilating fan, hay drier, mechanical milk cooler, milking machine, hot water heater, can rack and sink for washing hands. The silo unloader and barn cleaner are expected to be the greatest labor and time savers. The use of a flow diagram to check routes of feed distribution, movement of bedding, carrying of milk from cows to milk house and other farm chores is suggested as another means of cutting labor costs. C. J. Babcock

Also see abs. no. 29.

ICE CREAM

C. D. DAHLE, SECTION EDITOR

35. Chocolate coated ice cream. J. R. DEVOR. Can. Dairy Ice Cream J., **27,** 6: 34–36. June, 1948.

Chocolate coated ice cream bars are not advertised or displayed as much as other ice cream products or chocolate candies. The high cost of chocolate can be overcome by making a smaller bar, putting the chocolate on thinner and raising the price of the bar. In Canada there is a lack of trained chocolate temperers for the ice cream industry. Research work on chocolate has developed a satisfactory coating for ice cream. Ideal storage for chocolate is between 50 and 60° F. The chocolate should be processed between 140 and 160° F. and mixed. The heating before dipping will vary with the coating. It is important to keep all moisture out of and away from the chocolate, otherwise it will darken, thicken and become granular. H. Pyenson

36. Wrapper for frozen confections. S. B. SMITH. U. S. Patent 2,450,364. 3 claims. Sept. 28, 1948. Official Gaz. U. S. Pat. Office, **614**(4): 1019. 1948.

Frozen confections on a stick are enclosed in a paper wrapper which may be peeled as consumed, providing insulation and acting as a drip collector. R. Whitaker

37. The use of liquid sugar in ice cream. H. G. DUNLOP. Can. Dairy Ice Cream J., **27,** 7: 35–36. July, 1948.

Liquid sugar is an accepted standard ingredient in ice cream. The savings amount to 30 to 45 cents per cwt. No trouble has been encountered with fermentation. Crystallization was eliminated by insulating the tanks. The concentration of the sugar solids should not be more than 67%. Storage is not a problem when planning and scheduling is done properly. The amount of liquid sugar is measured by a meter on an auxiliary calibrated tank. The quality of liquid sugar is high. H. Pyenson

38. Liquid sugar for use in ice cream. ANONYMOUS. Ice Cream Rev., **31,** 3: 64, 66–68. Oct., 1948.

The use of liquid sugar as a standard ingredient of ice cream is increasing among the larger plants located near a source of supply. The installation of equipment for the efficient handling of liquid sugar usually is justified if the annual consumption of sugar is not less than 250,000 lb. The customary method of delivery is by stainless steel trucks with a capacity of 1,500 to 2,500 gallons or by tank cars holding from 6,000 to 10,000 gallons. Liquid sugar may be obtained as a pure water solution of sucrose, sucrose and invert sugar, or sucrose and corn syrup. If invert sugar is present, the amount should not exceed 15% because of the effect of the invert sugar on the freezing point of the mix. The liquid sugar for use in ice cream mix sometimes is measured by volume using special measuring tanks or meters. A more accurate method is to weigh the syrup with a tank-scale as it flows to the pasteurizer.

Liquid sugar in ice cream saves time and labor in handling, conserves valuable storage space since the storage tanks for liquid sugar can be located in areas where space is not at a premium, assists in streamlining plant operations, is more sanitary and offers less chance for waste or loss. Limitations of the product are the higher transportation costs because of the water contained in the product and the requirement of 2 storage tanks of large capacity in most cases to insure providing an adequate supply of the product on hand at all times.

W. J. Caulfield

39. Flavor materials. CARL KOERVER, Pioneer Ice Cream Div., The Borden Co., Brooklyn, N. Y.

Ice Cream Trade J., **44,** 10: 84, 164–173. Oct., 1948.

Coffee flavored ice cream is very popular in the New England States. It is consumed mostly by adults. Some coffee extracts have lost their caffein content, and ice cream flavored with these is safe for children to eat. No added color should be used since it detracts from the coffee flavor.

The amount of chocolate flavor will vary in different localities. Three to 4% by weight of cocoa and up to 7% of liquor chocolate may be used. This amount of chocolate flavor will add 0.5 to 3.5% cocoa butter to the ice cream; too much cocoa fat gives the ice cream a gummy and sticky body. About 3 quarts of chocolate syrup are used to make 5 gallons of mix. Chocolate ice cream needs more sugar than vanilla; sometimes 18 to 20% sugar is used. Milk solids may be reduced to 8 or 9% and the stabilizer cut one-half. From 4 to 6% chocolate flavor should be used. Straight liquor chocolate is not recommended.

Strawberries for ice cream should be packed with 1 part of sugar to 3 parts of berries; usually Marshal berries from Oregon and Blakemore and Missionary from the South are used. Care must be taken to make sure that all of the sugar is dissolved before the berries are frozen. Strawberry ice cream and most fruit ice creams can stand 19 to 21% sugar. It may be desirable to make a special mix for strawberry ice cream containing 12% fat, 12% serum solids and 12% sugar with highest limit of stabilizer. Seven gallons of this mix, and 3 gallons of 2 to 1 pack strawberries will give a combination testing 8.4% fat, 8.4% solids-not-fat and 20.5% sugar. Red raspberry puree, 3 to 1 pack, of grade B or better berries is recommended. The amount needed to flavor ice cream is 3 quarts of puree to 34 to 37 quarts of mix. Seedless black raspberry puree with a sugar content up to 50% may be used.

Peaches require special care in their preparation for freezing. When lye is used in the blanch to loosen skins, the blanched peaches should be run through a cold citric acid bath. Ascorbic acid is added to retard oxidation and browning. After blanching, the peaches should be cooled in very cold water. The amount of peaches necessary to impart a characteristic flavor to the ice cream is large, usually 20 to 35% of a 3 to 1 pack. A peach puree, made from whole pitted peaches with the skins, may be used in combination with fresh peaches, using 0.67 peaches and 0.33 puree. Use of green peaches should be avoided. Artificial peach flavor sometimes is used in combination with peaches. July 4 to Labor Day is the best season for peach ice cream.

Pineapple contains an enzyme which may produce a bitter almond and a "fishy" flavor, unless destroyed by heat. A 2.5 to 1 pack used at the rate of 2 to 2.5 gallons of pineapple to 8 to 7.5 gallons of mix is recommended. Sterilized canned pineapple is preferred by some manufacturers.

Montmorency sour pitted cherries are not satisfactory for ice cream. Black Bing and Royal Ann cherries, especially processed for ice cream, may be used. This ice cream is sold under the name of Whitehouse or Cherry Vanilla. Five to 6 quarts of drained cherries are used for each 10 gallons of mix.

For banana ice cream, a cold pack puree using 15 lb. to 10 gallons of mix is recommended. Since bananas brown readily, ascorbic acid, with or without citric acid, is added, and this does not affect the flavor of the ice cream.

Various nuts and candies are added to the white mix as flavor. Variegated or ripple ice cream rapidly is becoming one of the best sellers. W. H. Martin

40. The effect of some emulsifying agents on the physical-chemical properties of ice cream. J. J. Sheuring, Univ. of Ga., and H. Pyenson, Univ. of Ill. Southern Dairy Products J., **44,** 5: 104–105, 107–109, 114. Nov., 1948.

The emulsifying agents studied, glycerol monostearate, sorbitan monostearate and mannitol ester of stearin, react as fat in the fat tests, but 0.1 to 0.3% was not detected by modified Babcock methods and in a minority of the cases was not detected by ether extraction methods. These products do not have any preservative effect and do not produce any marked differences in pH, titratable acidity or mix viscosity. They reduce whipping and freezing time 10 to 25% and increase shrinkage. Emulsifying agents apparently offer no protection against heat shock. The decreases in body and texture scores in storage were less when gelatin was used with emulsifying agents than when the latter were used alone. The use of a stabilizer with an emulsifying agent is recommended to get the maximum efficiency from both.

F. W. Bennett

41. The advantages of emulsifiers in the manufacture of ice cream. H. L. Casler, Germantown Mfg. Co., Philadelphia 31, Pa. Southern Dairy Products J., **44,** 3: 28, 32. Sept., 1948.

Emulsifiers, like natural fats, belong to a

group of compounds known as esters, which are composed of fatty acids combined with alcohols. They differ from butterfat in that they contain more complex alcohols. If all the alcohol linkages are not taken up by fatty acids, emulsifiers have a greater affinity for both fat and water. Emulsifiers coat the homogenized fat globules and thus help to prevent clumping. Surface tension, the force which tends to pull the fat globules together to form larger masses, also is reduced. An emulsifier aids but cannot take the place of a stabilizer. Very few esters can be used as ice cream stabilizers. The proper amount of a suitable one must be determined by trial for each ice cream formula.

F. W. Bennett

42. The control of finished products in the ice cream plant. J. M. Brown, H. P. Hood & Sons, Boston, Mass. Southern Dairy Products J., **44,** 3: 108, 110, 112–113. Sept., 1948.

In the control of finished products in the ice cream plant, the route salesman makes his request for products wanted in duplicate. The original is used by the chestman to supply the goods. The duplicate is used by the cashier in settlement and by the shipper in loading. The chestman releases stock only on orders written on designated forms. The products are checked on to the truck with the route salesman. The route salesman is required to settle daily for all products in his possession. Discounts are confirmed by an approved customer list. A summary of all products shipped, transferred or sold is made daily and serves as part of the balance control report. F. W. Bennett

43. Full utilization of the ice cream plant laboratory. H. D. McAuleffe. Can. Dairy Ice Cream J., **27,** 7: 70–76. July, 1948.

Ice cream making no longer is an art but a science. Technological advances in the ice cream industry have been able to standardize the product to a great extent. Most plants have laboratories, but very few dairies utilize them fully. The time spent in diagraming the flow of materials through a plant and deciding exactly what samples are needed is well worth while. The standard plate count simply is a device to determine whether or not the other methods of control are working. Many laboratories can expand their functions. Examinations can be made on fruits, nuts, stabilizers, sugars, fuels, paints and other materials purchased if practical for the larger operations. The laboratory can be used as a part of the public relations program. H. Pyenson

44. Combination offer. Anonymous. Ice Cream Rev., **32,** 3: 46, 146. Oct., 1948.

A special combination offer consisting of a half gallon container of ice cream, an ice cream dipper and 24 ice cream cones priced to sell for $2.38 has been effective in building up carry-out sales. This combination of the merchandise was offered to the consumer for the first time during the month of July. It is reported that July sales on half gallons of ice cream were 73% greater than June sales on this item.

Display cards showing the items included in the combination offer and the price saving resulting from purchase of the combination were used to demonstrate and sell the idea to dealers and consumers. Dealer support of the combination offer was gained by capitalizing on the point that by encouraging customers to dip their cones at home the dealer would be able to reduce his sales on this short profit item.

W. J. Caulfield

45. Public relations for promoting dealer-consumer understanding of the ice cream industry. Ira Mosher. Ice Cream Trade J., **44,** 9: **34,** 69–72. Sept., 1948.

A survey conducted in New Jersey for a group of New York City and New Jersey ice cream manufacturers revealed that the majority of the retail dealers felt that they were being exploited by the manufacturers. Monthly news letters are being sent to some 8,500 dealers in an attempt to gain their confidence and expel this mistrust. These letters contain factual information on costs, profit possibilities, advantages of dealers, manufacturers cooperation, sanitation and prices.

W. H. Martin

46. Gallonage. V. M. Rabuffo. Ice Cream Trade J., **44,** 9: 32, 73–74. Sept., 1948.

Statistics released by the U. S. Bureau of Agricultural Economics show that ice cream production for the first 6 months of 1948 for the U. S. is running about 9% below that of 1947. In 2 of the states with the largest production, Pennsylvania and New York, production for the 6 months period was 4.4 and 6.6% below that of last year. W. H. Martin

47. Sales promotions and stimulators in merchandizing ice cream. H. A. Quitter. Can. Dairy Ice Cream J., **27,** 6: 48. June, 1948.

Helpful sales promotions and stimulators in merchandising ice cream are (a) bonus plans, (b) animated window displays, (c) bright cano-

pies, fluorescent lights and pictures, (d) proper servings and (e) bulk dipped ice cream.

H. Pyenson

48. Costs, a comparative analysis for a 5 year period. J. SHIPLEY, Abbotts Dairies, Philadelphia, Pa. Ice Cream Trade J., **44,** 10: 88, 162–163. Oct., 1948.

Costs of manufacturing and sale of ice cream in the North Atlantic district increased from 96 cents per gallon in 1941 to $1.16 in 1946. Most of the increase was due to higher products costs, which increased 62.2%, and greater manufacturing expense, which increased 4.9%. There were decreases of 24.3% in delivery, 15.6% in advertising and 29.9% in sales expense. The total net increase was 20.7% for the period.

W. H. Martin

MILK

P. H. TRACY, SECTION EDITOR

49. The effectiveness of milk ordinances. C. J. BABCOCK. Can. Dairy Ice Cream J., **27,** 7: 50–52. July, 1948.

Sanitation in milk production has not kept pace with the developments in plant sanitation. The sanitary control of the milk supplies of the U. S. ranges from practically no control to excellent control. Lack of enforcement and subterfuge in enforcement are responsible for a large percentage of the so-called grade A pasteurized milk that originates from raw milk containing a million or more bacteria per ml. The low salaries paid for milk control work contribute to the non-enforcement of milk ordinances. A majority of the milk ordinances on the statute books in the U.S.A. are not fully enforced. Therefore, it is impossible to judge a milk supply by the ordinance under which it is produced and handled.

H. Pyenson

50. Consumer evaluation of milk. W. A. WENTWORTH, The Borden Co., New York City. Milk Dealer, **37,** 11: 46, 94–98. Aug., 1948.

Dairy prices are relatively low. Retail prices of fluid milk and cream throughout the U. S. have not increased over prewar as much as have most of the other principal foods. The increase in the per capita use of milk and cream over prewar is not as much as with many other foods. Dairy products are economical to buy. The author concludes that to avoid consumer criticism and resistance to prices for all dairy products which will equalize the competitive production situation on the farms of this country, consumers must have a better realization of the money value of dairy products in comparison with other foods.

C. J. Babcock

51. Driver-owned milk routes. ANONYMOUS. Milk Dealer, **37,** 9: 52, 118. June, 1948.

Shelly Dairy Co., Lima, Ohio, completed 2 years of operations under a system whereby drivers own their own trucks, maintain them and in most cases keep their trucks at home overnight. They pay Shelly Dairy Co. 16 cents a quart for milk at the platform, and sell it at a delivered retail price of 20 cents, thus operating on a margin of 4 cents.

C. J. Babcock

52. Tarboro's municipally-owned milk plant. J. M. GREGORY, Whitaker, N. C. Milk Dealer, **37,** 12: 51–52, 88–90. Sept., 1948.

A description is given of the only city-owned dairy in the country. It is in Tarboro, N. C., a town of 10,000 population. The building is of brick construction 50 by 80 feet, 2 stories in front, 1 in the rear and cost $20,000. The equipment is less than 2 years old and is valued at approximately $16,000. About 500 gallons of sweet milk, 100 gallons of buttermilk and 100 gallons of chocolate milk are processed each day. About 200 gallons of sour cream are bought for butter and about 50 gallons of whipping cream are sold each week. The plant has been running successfully since 1918.

C. J. Babcock

53. Reducing operating costs with universal bottles. E. THOM, Assoc. Ed., The Milk Dealer. Milk Dealer, **37,** 9: 48, 110–115. June, 1948.

Some individuality and advertising value is lost to a milk dealer when the universal glass bottle is adopted in a market. In the face of rising costs, however, interest in the universal bottle as a means of reducing those costs is increasing. The universal bottle program saves the distributors many thousands of dollars yearly, but those savings are not as important as the fact that the program promotes a healthy market condition.

Akron, Ohio, is the latest market to adopt the universal bottle, and information on unit costs or bottle trippage is not available. In the Columbus, Ohio, market, the 1947 cost was $0.962 per 1000 units filled and the trippage on quarts was 36.6; on half-pints, 40.8; and the overall trippage for all bottles was 38.3. In Nashville during 1947 the market wide trippage was 35.57 and the unit cost was 1.2 mills. In Ft. Wayne, the dealers still were changing from one bottle to another, but the market had a

trippage of 34 on quarts, 24 on pints and 37 on half-pints. This gave a fillage cost of $0.0069. None of the above markets have a universal case. C. J. Babcock

54. Operation of the universal milk bottle plan in the Columbus market. W. K. HOLM, Columbus Milk Distributors Assoc., Columbus, Ohio. Milk Dealer, **37,** 11: 41, 74. Aug., 1948.

Surveys have shown that the container cost ranges from 0.06 cent to over 1 cent per unit filled, which is from 0.3 to 5% of the total cost. The main factors affecting container costs are the original cost of container, the number of times a container is used, the deposit on a bottle if not returned, time consumed sorting foreign bottles, and the expenses involved in getting strayed bottles back.

The low bottle cost experienced with the universal bottle plan is due to: (a) Purchase of bottles in larger quantities and thus at a lower price when all dealers are using the same bottle. This saving is from 65 cents to over $4.00 per gross, except for dealers who already are buying in large enough quantities to receive the lower price. At the present time one obtains the lowest price per gross if buying 3,000 gross a year. (b) The exchange of bottles is eliminated, saving time, storage space and transportation of bottles. (c) The elimination of the exchanging saves considerable wear and breakage of bottles. (d) More effective returns on the bottles from the consumer results. (e) Fewer bottles are tied up in inventory. (f) A uniform bottle deposit plan is used.

In addition to lower costs, other advantages are: (a) Grocers and milkmen are not bothered with more than one type of bottle. (b) Housewives have less difficulty returning bottles. (c) Such a plan tends to promote better relations between competing dealers.

The one single disadvantage to the universal bottle plan is that the individual advertising value of a dealer's own bottle is lost.

C. J. Babcock

55. Consumers' acceptance of the paper milk bottle. R. C. MILLER, Country Charm Dairy, Monticello, Ill. Milk Dealer, **37,** 11: 102–106. Aug., 1948.

A questionnaire was placed in the hands of about 500 consumers. Among the advantages of paper bottles which were mentioned, 84 reported more sanitary, 80—easier to dispose of than wash and return bottle, 71—no bottle washing, 57—saves storage space, 53—more convenient, 46—no bottle return, 45—much safer to handle, 10—lighter than glass, 5—no bottle accumulation, 4—no bottle deposit, 4—pour off more cream than glass, 3—easier to open than glass, 2—makes good frozen food storage containers, 1—protects milk from light and 1—will not freeze and break if housewife is not home. Among the disadvantages, 7 people mentioned paraffin scrapes off and falls in other food, 5—hard to pour, 3—hard to open, 3—dogs carry away, 2—paraffin taste, 2—can't clean outside well before storing, 2—can't pour out all the milk and 2—bottles not always full. C. J. Babcock

56. Milk cans versus tank trucks. G. D. ARMERDING. Can. Dairy Ice Cream J., **27,** 7: 40–42. July, 1948.

The tank method is not practical for farms producing less than 300 gallons of milk per day. The advantages of the tank system are: (a) effective cooling with less risk of temperature rise; (b) eliminates all contact with oxidizing metals; (c) lower temperatures can be maintained while the product is in transit and all danger of freezing is avoided; (d) air-bourne contamination is eliminated; (e) no milk needs to be rejected due to high temperature spoilage; (f) spillage and sticking losses are avoided; (g) requires a minimum of hard labor on the farm and in the plant; (h) saves space on the farm and in the dairy; (i) makes possible every other day pick-up; (j) better control can be maintained by the dairy inspector; (k) the farmer can check his own weights on the farm; (l) elevated highways at milk plants no longer would be necessary and (m) the noise of can handling would be eliminated. H. Pyenson

57. Top milk extractor. F. H. VALETON. (one half assigned to C. D. Colbert.) U. S. Patent 2,450,313. 2 claims. Sept. 28, 1948. Official Gaz. U. S. Pat. Office, **614**(4): 1007. 1948.

The top milk is removed from a bottle of milk by introducing a liquid through a tube extending beneath the cream layer. The top of the bottle is sealed except for an outlet from which the top milk is collected. R. Whitaker

58. Economics of milk cooling. L. P. BLAUSER, Ohio State Univ. Milk Dealer, **37,** 11: 110–112. Aug., 1948.

The results of an Illinois experiment where samples of milk were held at different temperatures for a period of 12 hr. are reported. At 40° F. there was no increase in bacteria. At 50° F. the increase was slight. At 60° F. each bacterium produced 15 new ones. At 70° F. each

bacterium produced 700 new ones. At 80° F. each bacterium produced 3,000 new ones. The efficiency and cost of cooling milk with water, ice and mechanical refrigeration are compared. The author concludes that when the requirement for milk to be cooled to 50° F. more generally prevails, the use of electric milk coolers will become more universal, for it is the exceptional case where a well or spring has water of sufficiently low temperature to cool milk to 50° F.

C. J. Babcock

59. Homogenized milk problems. P. H. Tracy, Dept. of Food Technol., Univ. of Ill., Urbana. Milk Dealer, **37,** 11: 49–54. Aug., 1948.

The author points out that, next to pasteurization, the process of homogenization probably has done more than any other thing to increase the popularity of milk as a beverage. The process of homogenization is described. Fat rising in homogenized milk, curd tension reduction, sediment control, homogenization of extra rich milk, control of the bacterial content, testing for fat and flavor control are discussed.

C. J. Babcock

60. Fat free milk as a special dairy product. C. P. Segard, Wis. Alumni Research Foundation, Madison. Milk Dealer, **37,** 12: 55, 106–110. Sept., 1948.

Fat-free milk as a special dairy product and its use in the diet is discussed. Fluid milk and its by-products long have been recognized as the leading food product. There are many conditions recognized by physicians and surgeons where a high protein diet is required, and a high protein-low fat diet is easily acquired by the use of fat-free milk. It is recommended that vitamin A and D be added to the fat-free milk to offset the loss in the fat and to assure an intake of these vitamins that will offset any tendency toward deficiency. Since the medical profession has repeatedly shown the need for such a product, the Medical Milk Commission would seem to be the logical group in whose hands to place the quality responsibility. Those interested in the production of certified milk and those interested in the nutritional importance of fat-free certified milk may become responsible for such a product fortified with 4,000 U.S.P. units of vitamin A and 400 U.S.P. units of vitamin D.

C. J. Babcock

61. How to make a high quality chocolate-milk or dairy drink. B. P. Forbes, Benjamin P. Forbes Co., Cleveland, Ohio. Milk Dealer, **37,** 10: 82–84. July, 1948.

The effect of a variation in milk solids on the quality of chocolate milk and ways of increasing its flavor are discussed. It is pointed out that a good chocolate milk drink, one that will repeat and be a trade builder, should have a mild, pleasant milk chocolate flavor, little or no sedimentation, low to medium viscosity, light to medium color and medium sweetness.

The 2 most frequent defects in chocolate milk are settling and thickening or gelling. Settling may be caused by: (a) insufficiently stabilized cocoa for the amount of milk base to be processed; (b) too much milk or insufficient butterfat content for the amount or type of chocolate flavor used; (c) dilution of dairy drink by milk or water left in lines from pasteurizer to bottler; (d) restriction of valves on pressure side of pumps, causing a homogenizing effect of excessive whipping by centrifugal pumps; (e) too acid milk (keep acidity below 0.15%, but not by neutralizing); (f) using soda-neutralized milk; (g) using frozen milk (also causes wheying off); (h) incorrect pasteurization and cooling; (i) insufficient heat or too short holding time; (j) over agitation during and after cooling; (k) powder not entirely incorporated in the milk base; (l) not cooled to 40° or lower; (m) precooling below 140° in vat.

Thickening or gelling may be caused by: (a) excessive pasteurizing temperature; (b) too much stabilized chocolate flavor used, causing over stabilization; (c) use of lime or magnesium neutralizers; (d) improperly rinsed bottles; (e) too high acid milk. C. J. Babcock

62. Recent technological advancements in the dairy industry. J. H. Hetrick, Dean Milk Co., Rockford, Ill. Milk Dealer, **37,** 9: 156–162. June, 1948.

The dairy industry has been the beneficiary of many phases of chemical, bacteriological and engineering developments and "know-how". The application of scientific knowledge in many interrelated fields has made it possible for the industry continually to improve its products, to increase efficiency in production and distribution and to meet the increasing demand for these products. New products and new uses for old products have been developed. The keeping quality of the products has been improved through newer knowledge of processing, packaging and storage and through improved control practices. The nutritional properties have been enhanced. Methods for utilization of surpluses have been discovered to the economic advantage of the industry and the consumers of its products.

One of the most important essentials in the production of good milk is clean sterile milk handling utensils and equipment. Research has

developed cleaning aids specifically designed to handle milk wastes, and effective chemical sterilizers for the job. Research has produced analytical tools and a better understanding of the analytical methods used, such as the methylene blue test, the resazurin test, plate and direct microscopic bacteria counting, the sediment test, etc. These aid in assessing milk quality at the plant.

The biggest factor that led to the acceptance of pasteurization was definite proof that numerous epidemics of contagious diseases frequently were traced directly to contaminated milk. It also was well demonstrated in the laboratory that proper pasteurization would do the job of destroying the organisms responsible for the disease. The development of more efficient heaters, sensitive control devices and research on bacterial destruction brought about the approval and use of high temperature short time continuous pasteurization. Studies in ultrasonics, X-radiation and ultra violet radiation, etc., may culminate in improved sterilized dairy products. Research on the nutritional properties of milk has led to vitamin D milk which today is accepted as one of the most outstanding contributions of dairy research to public health. Research on homogenized milk has been responsible for the rapid acceptance of this product. Technological know-how has been used in the manufacturing, packaging and storage of dried milk, dried ice cream mix, dried cream, sterilized dairy drinks, frozen milk, frozen concentrated milk, butter oil and army spreads. There has been an increased realization of the necessity for and the value of scientific research, development and laboratory control. C. J. Babcock

Also see abs. no. 8, 9, 10, 11, 14, 15, 18, 20, 25, 27, 34.

MILK SECRETION

V. R. SMITH, SECTION EDITOR

63. Effects of steroids on lactation. J. C. Barsantini, and G. M. C. Masson, Univ. of Montreal. Endocrinology, **41,** 4: 299. Oct., 1947.

Female albino rats weighing 250–300 g. and fed Purina Fox Chow were used. Within 24 hr. of parturition, the litters were either reduced or brought up to 6. Steroid treatment was started immediately, and some of the rats were ovariectomized. Efficiency of lactation was estimated by the gains in body weight of the young and by the number of deaths among the young. In normal rats estradiol at daily doses of 10 γ and 1 mg., and testosterone, androstenediol, dehydro-iso-androsterone at a daily dose of 10 mg. caused a marked inhibition of lactation. At the daily dose of 10 mg., androstenedione, methyl androstenediol, methyl androstanediol, ethyl testosterone, ethynyl testosterone, ethynyl androstenediol and methyl testosterone produced a definite but much less marked inhibitory effect. Desoxy-corticosterone, pregnenolone, acetoxypregnenolone, and progresterone were inactive. All of the steroids were inactive in spayed lactating rats. Ralph P. Reece

Also see abs. no. 66.

PHYSIOLOGY AND ENDOCRINOLOGY

R. P. REECE, SECTION EDITOR

64. Clinical and postmortem observations on metrorrhagia in the virgin heifer. A. F. Weber, B. B. Morgan, and S. H. McNutt, Univ. of Wis., Madison. North Am. Veterinarian, **29,** 11: 705–710. Nov., 1948.

Sixty-eight complete estrus cycles were studied in 22 clinically normal virgin heifers. Several estrus cycles were observed in each heifer, and they then were slaughtered during proestrus, estrus and the first 4 days post estrus and used for postmortem studies. Uterine motility was studied by rectal palpation. Evidence of uterine bleeding was macroscopically observed in 55 of the 68 cycles followed. Vaginal swab studies showed the presence of microscopic bleeding in the remainder of normal estrus periods. The average time of appearance of uterine bleeding in the 55 macroscopic cases was 36 hr. after the onset of estrus. Endometrial edema, as determined by postmortem studies, began during early proestrus and reached a maximum at the time of ovulation. Rectal palpation revealed regular uterine contractions during the interestrus and estrus periods, with maximal contraction at the time of estrus. Following ovulation the uterus was in a quiescent condition for several days with only irregular partial muscular contractions. R. P. Niedermeier

65. Effect of adrenalectomy on the mammary gland of the castrated and estrogen treated castrated male rat. J. J. Trentin, and C. W. Turner, Univ. of Mo. Endocrinology, **41,** 2: 127. Aug., 1947.

In Wistar male rats weighing from 200 to 300 g., castration resulted in a reduction but not complete elimination of the alveolar development normally found in the mammary glands of adult males. The removal of the adrenals of castrated male rats, with maintenance on 1% saline for 10 days, resulted in atrophic ducts and in com-

plete regression of the alveolar development. In adrenalectomized, castrated rats maintained on salt the daily administration of 5 γ of α-estradiol benzoate for 10 days, although causing noticeable duct stimulation, was relatively ineffective in stimulating alveolar growth as compared with castrated rats. Ralph P. Reece

66. The role of the adrenal cortex in mammary development and its relation to the mammogenic action of the anterior pituitary. A. T. Cowie and S. J. Folley, Nat. Inst. for Research in Dairying. Endocrinology, **40,** 4: 274. April, 1947.

Immature hooded Norway rats of both sexes, gonadectomized either at weaning or a few days thereafter, were used. In 1 experiment, the adrenals were removed at the time of gonadectomy; in 2 experiments adrenalectomy was postponed until some weeks after weaning. Adrenalectomized rats received saline for drinking water. Some rats received daily subcutaneous injections of a saline extract of ox anterior pituitary, 1 ml. of which was equivalent to 250 mg. fresh tissue. A semi-quantitative method of scoring the kind and degree of glandular development was devised and used. Regressive changes in the mammary glands frequently were observed following adrenalectomy; increased arborescence of the duct system never was observed. The pituitary extract showed mammogenic activity both in the presence and absence of the adrenals, duct growth being most prominent in the youngest rats, while in older rats stimulation of alveolar development also occurred. Adrenalectomy sometimes altered the mammogenic effects of the anterior-pituitary extract; however, the results indicated that the mammogenic action of the extract was not due primarily to its stimulation of the adrenal cortex. Alveoli eventually developed in the mammary glands of untreated rats gonadectomized when sexually immature. Ralph P. Reece

67. Hyaluronidase levels of rat testes as related to age, hypophysectomy and cryptorchidism. S. L. Leonard, P. L. Perlmar, and R. Kurzrok, Cornell Univ. Endocrinology, **42,** 3: 176. March, 1948.

Hyaluronidas determinations were made on testes of rats of varying ages by the turbidimetric method and by the rat-ova test. Testes homogenates were prepared in acetate buffer at pH 6 for the turbidimetric tests and in Ringer's solution for the rat-ova test. The amount of enzyme per g. of tissue gradually increased between 21 d. of age and sexual maturity. The hyaluronidase level was low by the tenth day following experimental cryptorchidism and by the 24th day after hypophysectomy. Enzyme levels and the degree of development of the germinal epithelium were correlated directly. All of the hyaluronidase was not accounted for by mature sperm, since it was detected in testes devoid of sperm.

Ralph P. Reece

68. Effects of vitamin A deficiency on thyroid function studied with radioactive iodine. M. B. Lipsett, and R. J. Winzler, Univ. Southern Calif., School of Medicine. Endocrinology, **41,** 6: 494. Dec., 1947.

Using radioactive iodine as a tracer, the functioning of the thyroid gland of the rat was investigated in severe avitaminosis A. The thyroid glands of vitamin A deficient rats were relatively heavier than in control animals and the histological picture showed degenerative changes and distended follicles present within the same gland. The total I^{131} uptake of thyroid glands from vitamin A deficient rats was similar to that of glands from control rats. The percentage of inorganic I^{131} in the thyroid gland of vitamin A-deficient rats reached higher values and decreased more slowly than in the controls. There was a significantly lower rate of thyroxine formation in the vitamin A-deficient rats and a decreased final level at 96 hr. Ralph P. Reece

Also see abs. no. 30, 63.

SANITATION AND CLEANSING

K. G. WECKEL, SECTION EDITOR

69. Laboratory procedure for evaluating practical performance of quaternary ammonium and other germicides proposed for sanitizing food utensils. G. R. Weber and L. A. Black, U. S. Public Health Service, Cincinnati, Ohio. Am. J. Pub. Health, **38,** 10: 1405–1417. Oct., 1948.

Five ml. of a suspension of a test organism containing 200 million organisms per ml. was mixed with 5 ml. of the germicide whose concentration was twice that desired for testing. The time required to obtain a 100% kill of the organisms by the germicide used indicated the exposure time required for sanitizing food utensils. The test organisms used were *Escherichia coli, Staphylococcus aureus* and *Micrococcus caseolyticus. E. coli* was preferred as the test organism, since the others gave a reduced killing time. Using distilled water instead of tap water to prepare the germicidal solutions also shortened the killing time. An alkaline hypochlorite of 50 p.p.m. available chlorine gave 100% kills in 30 seconds, while a chloramine T solution of 200 p.p.m. required 120 seconds. Some quaternaries gave a

100% kill of *E. coli* in 60–120 seconds when recommended concentration, usually 200 p.p.m., was used. Other quarternaries did not give complete kills even after 5 min. exposure.

D. D. Deane

70. The effect of quaternary ammonium sanitizers on the quality of milk. A. V. Moore, Texas A. & M. College. Southern Dairy Products J., **44,** 5: 62–64. Nov., 1948.

Fresh raw milk in 100 ml. quantities was treated with from 0 to 175 p.p.m. of 3 well known quaternary ammonium sanitizers. A duplicate set of samples was prepared and 2 ml. of active starter added to each sample. All samples were incubated at 70° F. and examined after 20 and 40 hr. After 20 hr. the titratable acidity of the samples without starter or sanitizer was 0.68 to 0.71%. The acidity of the samples containing 25 p.p.m. of quaternary sanitizer ranged from 0.51 to 0.67%, while the acidity of those containing from 50 to 175 p.p.m. varied from 0.30 to 0.20%. The samples containing 2 ml. each of starter without sanitizer had an acidity of 0.85 to 0.86%. Those containing starter and 25 p.p.m. of a quaternary sanitizer varied from 0.50 to 0.70% in acidity while the acidities of those containing from 50 to 175 p.p.m. ranged from 0.41 to 0.24%. All except 1 of the 36 samples containing 50 p.p.m. or more of a quaternary sanitizer had musty, putrid or stale odors. After 40 hr., the samples containing 25 p.p.m. of a quaternary sanitizer, with or without starter, had acidities ranging from 0.42 to 0.86%. The acidities of all samples containing from 50 to 175 p.p.m. of a quaternary sanitizer ranged from 0.69 to 0.23%.

The samples containing 25 to 175 p.p.m. of available chlorine all were normal in odor and acidity except 2 without starter which had a chlorine odor. The addition of sanitizers to milk is very detrimental to the quality of the milk, as well as being an illegal practice.

F. W. Bennett

71. Present status of chemical sterilizers. D. V. Josephson, Dept. of Dairy Husb., Penn. State College. Milk Dealer, **37,** 12: 102–104. Sept., 1948.

Chlorine sterilizers are compared with the quaternary ammonium compounds. The latter compounds have certain advantages in that they are non-toxic, odorless, non-corrosive, stable to heat and air, not greatly affected by alkaline conditions, not as reactive with organic matter and have wetting and penetrating powers. They have certain disadvantages in that the various types are not equally effective, and reliable and simple means of analysis have not yet been developed. Furthermore, the quaternary agents are liquids and are more costly to use. They are not compatible with soaps, certain phosphates, silicates and anionic wetting agents. C. J. Babcock

72. Sanitizing milking machines. A. C. Dahlberg. Can. Dairy Ice Cream J., **27,** 7: 60–62. July, 1948.

Boiling water was an effective germicide but was hard on the rubber. Later a concentrated brine solution in a crock was used on the rubber parts as a disinfectant. Then chlorine was added to the salt brine. The solution racks have now replaced the crock and the chlorine has been replaced by 0.4% lye solution. More recently new water softeners and the complex phosphates aided in cleaning and preventing mineral deposits in the rubber parts. The nontoxic cationic germicides are more or less stable in nature and offer a new attack in sterilization, but some of them are not compatible with water softening compounds and surface active detergents. H. Pyenson

73. New developments in sanitizing teat cups. W. S. Mueller and D. B. Seeley, Univ. of Mass., Amherst. Hoard's Dairyman, **93,** 21: 807. Nov. 10, 1948.

One extra milker head assembly for every 2 complete milking machines used is recommended as a means of increasing contact time between teat cup and germicide. Germicidal solutions were made up to contain 400 p.p.m. Approximately 20 teat cups were examined for bacteria after being treated as follows: (a) before use after being stored in lye solution, (b) after milking 1 cow but not being rinsed in water or sanitized, (c) after rinsing in cold water and sanitizing for 1 sec. in the quaternary solution, (d) after rinsing in cold water and sanitizing for 2 min. in the quaternary solution. The extra milker head remained in the germicidal solution when not in use and was alternated from one machine to the other between cows. The teat cups were sanitized between cows milked for 2 minutes or more without increasing the milking time of the herd. Where the extra head was used the total bacterial count of the teat cup was reduced considerably and 99.7% of *Str. agalactiae* organisms were killed under laboratory conditions.

J. B. Frye, Jr.

74. Sanitation for the dairy farm. M. P. Baker, Iowa State College, Ames. Milk Dealer, **37,** 9: 98–104. June, 1948.

Quality milk is defined as meaning clean milk

of good flavor, of low bacterial content and containing no harmful microorganisms such as pathogenic bacteria. Clean cows, sterile utensils and prompt cooling are major factors in the production of milk with low bacterial content. Healthy cows, healthy, clean milkers and milk handlers, safe farm water supplies and protection from flies are factors that guard against undesirable types of contamination. These are not necessarily expensive. Many of the items important in the production of high quality milk also are important from the standpoint of efficiency of dairy farm operation. C. J. Babcock

75. You can clean up with less. H. F. KERN, JR., Freeman's Dairy, Allentown, Penn. Milk Dealer, **37,** 11: 43, 67. Aug., 1948.

The biggest waste of washing powder was due to the large bucket of powder that normally was kept in each department. It was too easily accessible, and there was a tendency to use a scoopful when a teaspoonful would have been sufficient. An educational program, including bagging the powder into convenient lb. packages and dispensing it in correct amounts to each workman for his respective job, resulted in a reduction in the quantity of powder used.

C. J. Babcock

76. Prevention of insects in dairy plants. ED. M. SEARLES, Sealtest, Inc. Milk Dealer, **37,** 10: 48, 86–90. July, 1948.

The discussion may be summarized as follows: (a) keep insects out of plant, (b) clean out breeding and hiding places, (c) use 5% DDT in odorless kerosene by trained personnel, (d) use the proper sprayer, (e) spray only the insect resting, roosting and hiding places and (f) never let the spray fall into or onto food or into containers used for holding food. C. J. Babcock

77. Forty years of progressive dairy sanitation. R. S. BREED. Can. Dairy Ice Cream J., **27,** 7: 43–49. July, 1948.

The article discusses the progress made in dairy sanitation and gives an outline of determinative bacteriology. H. Pyenson

Also see abs. no. 17, 22.

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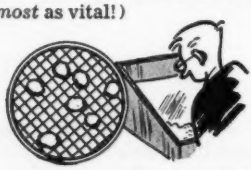

Happily for the mouse, he got results. And so do we at Diamond Crystal. That's why you can always be sure of clean screening whenever you specify Diamond Crystal. Take your choice of grade or grain size—it's tops by actual tests!

Want Free Information on Salt? Write Us!

If *you* have a salt problem, let our Technical Director help! Just drop him a line in care of Diamond Crystal Salt, Dept. H-11, St. Clair, Michigan.

DIAMOND CRYSTAL
ALBERGER PROCESS **SALT**

The Name to Remember

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DAIRY PRODUCTS

Pure-Pak Division,
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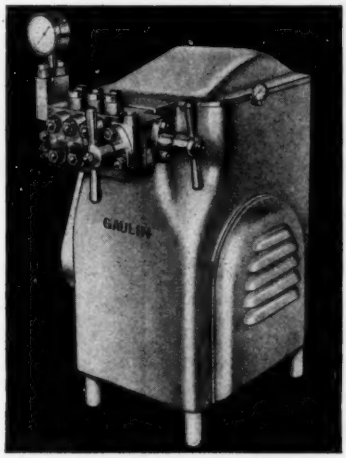

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The New Model "E" Is The World's Most Modern Homogenizer . . . Made Specifically For The Smaller Processor.

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For Clean, Sparkling Bottles

use ORVUS

Orvus, the time-tested wetting agent and synthetic detergent

—speeds cleaning action
—boosts the efficiency of the alkali
—assures thorough emulsification
—reduces bottle re-runs, particularly on chocolate drink bottles
—decreases solution drag-out by greatly lowering surface tension

Orvus loses none of its cleaning efficiency in hardest water. Easy to use... economical . . . a little goes a long way in your soaker tanks.

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THE RESAZURIN TEST

Sterile dry capped 3 dram vials, containing the correct amount of dry dye, ready to receive the sample of milk.

$6.00 per gross f. o. b.
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A resazurin color comparator with four colors contained in walnut case for use with above vials $8.00

This makes a SAVING for you in
TIME and MONEY

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State College of Washington
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THE CULTURE
of definitely better flavor & aroma producing qualities.
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FLAV-O-LAC FLAKES
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See our catalog in Dairy Industries Catalog

Marschall
RENNET and COLOR

Strong, clean Rennet is important in the making and curing of cheese. Use Marschall Rennet generously for maximum results.

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Sparkling CLEAN MILK CANS

with

ACID-KLENZ AND THE Chem-O-Shot FEEDER

Acid-Klenz is an organic acid detergent that is highly effective for the removal of milkstone and the retarding of bacterial growth on all milking and milk producing equipment.

Dairy farms and plants as well as cream stations find it equally effective for stabilizing hard water, emulsifying milk fats and suspending milk solids quickly and effectively.

Chem-o-Shot proportioning equipment gives accurate control to predetermined pH level for guaranteed results.

Write for special literature describing fully the Klenzade method of maintaining Sparkling Clean Milk Cans.

KLENZADE

KLENZADE PRODUCTS
INCORPORATED
BELOIT, WISCONSIN

CHEMICAL CLEANING SPECIALISTS SERVING THE DAIRY INDUSTRY WITH CONVENIENTLY LOCATED BRANCH OFFICES, WAREHOUSES AND DISTRIBUTORS IN PRINCIPAL CITIES THROUGHOUT THE NATION

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gives dairy plant operators more complete, efficient, convenient, economical cleaning and disinfecting. Technical information available upon request. Your inquiry is invited.

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A technical service which contributes so much to the Dairy Industry is worthy of the recognition accorded to other scientific achievements in the same field.

The technician engaged in this work is a true specialist who requires special equipment, designed and manufactured for a special purpose.

The period of makeshift and improvised apparatus is past.

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The new CP No. 160 Stainless Vacuum Filler, exhibited for the first time at the recent Dairy Industries Exposition, has been field tested in actual plant operation. The special Show Conveyor shown in the picture was used for continuous capping and return of bottles.

As efficient as it is beautiful, the new CP Vacuum Filler *can be operated as a gravity filler,* if ever necessary, with but a few quick minor adjustments, thus assuring uninterrupted service.

The New No. 160 is equipped with 16 leak- proof valves and six CP Stainless Steel "Take-Down" Capping Heads, it has a top speed of 120 bottles per minute and handles up to 90 qts. per minute.

Ask your CP Representative for complete details of CP's sensational new vacuum filler.

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CULTURE MEDIA
for Examination of Milk

BACTO-TRYPTONE GLUCOSE EXTRACT AGAR

is recommended for use in determining the total bacterial plate count of milk in accordance with the procedures of "Standard Methods for the Examination of Dairy Products" of the American Public Health Association.

Upon plates of medium prepared from Bacto-Tryptone Glucose Extract Agar colonies of the bacteria occurring in milk are larger and more representative than those on media previously used for milk counts.

BACTO-PROTEOSE TRYPTONE AGAR

is recommended for use in determining the bacterial plate count of Certified Milk. The formula for this medium corresponds with that suggested in "Methods and Standards of Certified Milk" of the American Association of Medical Milk Commissions.

BACTO-VIOLET RED BILE AGAR

is widely used for direct plate counts of coliform bacteria. Upon plates of this medium accurate counts of these organisms are readily obtained.

BACTO-BRILLIANT GREEN BILE 2%

BACTO-FORMATE RICINOLEATE BROTH

are very useful liquid media for detection of coliform bacteria in milk. Use of these media is approved in "Standard Methods."

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